Spitzer Space Telescope - Archive Research Proposal #20309

PAH Emission Features in the 15 to 20 Micron Region: Emitting to the Beat of a Different Drummer

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Science Category: ISM
Dollars Approved: 72000.0

Abstract:
Spitzer has added a new complex of bands near 17 um to the PAH emission band family. This 17 um band complex, the second most intense of the PAH features, carries unique information about the emitting species. Because these bands arise from drumhead vibrations of the hexagonal carbon skeleton, they carry information directly related to PAH shape, size, and charge. Further, since much of the emission at these wavelengths originates from PAHs at the small end of the very small grain (vsg) population, this provides the first glimpse into details of the vsg population on a molecular level. Since the information contained in this band is fundamentally different from that of the mid-IR features and it probes the vsg population, the 17 um band complex is an important new tool with which to probe conditions within the Galaxy and in extragalactic star forming regions and simultaneously gives insight into the cosmic history of the important biogenic element, carbon. However, since little is known about PAH spectroscopic properties at wavelengths longer than about 15 um, it is impossible to utilize the 17 um band complex as a new astronomical investigative tool. We propose a laboratory study to remedy this situation. We will measure the 15 to 20 um spectra of PAHs which vary in size, shape, and ionization state. Spanning the range from C30H14 to C132H34, the PAH sample varies from moderately sized PAHs to the largest PAHs available anywhere. We will combine these experimental studies with quantum computations to test and perfect the computational approach for this new wavelength and fundamental vibration regime. The laboratory work will provide data with which one can analyze the new 17 um emission band complex and will ultimately be used to develop computational techniques to model the longer wavelength spectra of much larger PAHs. We will make these spectra available on the web and develop protocols for analyzing the Spitzer spectra and publish this procedure so it is accessible to the community.

Spitzer Space Telescope - Archive Research Proposal #30144

Diamonds are a PAHs Best Friend

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Science Category: ISM
Dollars Approved: 56727.0

Abstract:
The mid-IR spectroscopic capabilities and unprecedented sensitivity of the Spitzer Space Telescope has shown that the ubiquitious infrared (IR) emission features can be used as probes of many galactic and extragalactic objects. These features, formerly called the Unidentified Infrared (UIR) Bands, are now generally attributed to the vibrational emission from polycyclic aromatic hydrocarbons, PAHs, and related species. However there is some difficulty in reproducing all the features of the interstellar emission spectrum solely with PAH spectra. Because these differences have persisted as our knowledge of PAH spectroscopy has increased these differences point to at least one other type of contributor to the interstellar emission spectrum. The association of these features with objects abundant in cosmic carbon points to an additional carbonaceous material contributing to the features. Among the possibilities diamonds are particularly attractive. However, until very recently, this could not be tested because well-characterized microdiamonds were not available for study. These are now available for purchase from ChevronTexaco. We propose to use the matrix isolation technique to measure the 0.7 to 20 μm spectra of astrophysically relevant, cold microdiamonds. We will also develop and apply the computational techniques required to calculate these spectra and the spectra of microdiamonds for which we cannot obtain samples. Given the lack of availability of microdiamonds until recently, their IR spectroscopic properties are not known. Since microdiamonds have been long thought to be present throughout the ISM this lack of spectroscopic information prevents a complete analysis of Spitzer data, especially in the 7 to 8 μm region. These data will be made available to the astronomical community. Incorporating these new data into existing models will improve their ability to probe conditions such as radiation field, charge state, electron and hydrogen density, and cosmochemical history of the object.

Spitzer Space Telescope - Archive Research Proposal #40131

PAH Spectra for Everyone

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Science Category: ISM
Dollars Approved: 40000.0

Abstract:
The Ames Astrochemistry Laboratory now has PAH IR spectra of more than 220 laboratory measured and over 600 theoretically calculated IR spectra of polycyclic aromatic hydrocarbons (PAHs) in a multitude of forms. The vast majority of these spectra are not readily accessible to the public. We propose to make the full collection of the Ames experimental and computational collection of PAH IR spectra available to the entire Spitzer community and accessible via the World Wide Web (WWW). The laboratory measured mid-IR spectral collection includes over 220 neutral, cationic, and anionic PAHs, PAHs with deuterium in place of hydrogen, PAHs containing oxygen, and PAHs containing nitrogen (PANHs). The formulae of the PAHs in the experimental data collection range from C10H8 to C50H22. Unfortunately, it is not possible to obtain physical samples of all of the types of PAHs that are of astrophysical interest for experimental study. We also have an extensive collection of accurate computational spectra to fill in gaps in the experimentally available spectra. Our theoretical PAH spectral collection includes very large PAHs, PAHs containing 40 to 132 carbon atoms which are comparable to the size of the PAHs thought to dominate the interstellar emission spectrum. Large PAHs might be multiply charged and these are also represented in the theoretical database. There is also observational evidence for PAH cations with nitrogen in the inner rings (PANHs) and interest in the spectroscopy of aromatic species containing oxygen and deuterium as well as PAH metal clusters. All of these types of PAHs are represented in the Ames computational PAH IR spectroscopic collection. If funded, we plan to make our entire inventory of the lab spectra available to the Spitzer community within the next two years.

Spitzer Space Telescope - Archive Research Proposal #40364

IR Spectroscopy of PAHs in Dense Clouds

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Institution: NASA Ames Research Center

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Co-Investigators:
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Scott Sandford, NASA Ames Reserach Center
Max Bernstein, NASA Ames Research Center

Science Category: ISM
Dollars Approved: 63016.0

Abstract:
Interstellar PAHs are likely to be a component of the ice mantles that form on dust grains in dense molecular clouds. PAHs frozen in grain mantles will produce IR absorption bands, not IR emission features. A couple of very weak absorption features in ground based spectra of a few objects embedded in dense clouds may be due to PAHs. Additionally spaceborne observations in the 5 to 8 ?m region, the region in which PAH spectroscopy is rich, reveal unidentified new bands and significant variation from object to object. It has not been possible to properly evaluate the contribution of PAH bands to these IR observations because the laboratory absorption spectra of PAHs condensed in realistic interstellar mixed-molecular ice analogs is lacking. This experimental data is necessary to interpret observations because, in ice mantles, the interaction of PAHs with the surrounding molecules effects PAH IR band positions, widths, profiles, and intrinsic strengths. Furthermore, PAHs are readily ionized in pure H2O ice, further altering the PAH spectrum. This laboratory proposal aims to remedy the situation by studying the IR spectroscopy of PAHs frozen in laboratory ice analogs that realistically reflect the composition of the interstellar ices observed in dense clouds. The purpose is to provide laboratory spectra which can be used to interpret IR observations. We will measure the spectra of these mixed molecular ices containing PAHs before and after ionization and determine the intrinsic band strengths of neutral and ionized PAHs in these ice analogs. This will enable a quantitative assessment of the role that PAHs can play in determining the 5-8 ?m spectrum of dense clouds and will directly address the following two fundamental questions associated with dense cloud spectroscopy and chemistry: 1- Can PAHs be detected in dense clouds? 2- Are PAH ions components of interstellar ice?

Spitzer Space Telescope - Archive Research Proposal #50257

IR Spectroscopy of PANHs in Dense Clouds

Principal Investigator: Louis Allamandola
Institution: NASA Ames Research Center

Technical Contact: Louis Allamandola, NASA Ames Research Center

Co-Investigators:
Andrew Mattioda, NASA Ames Research Center
Scott Sandford, NASA Ames Research Center

Science Category: ISM
Dollars Approved: 75000.0

Abstract:
Interstellar PAHs are likely to be frozen into ice mantles on dust grains in dense clouds. These PAHs will produce IR absorption bands, not emission features. A couple of very weak absorption features in ground based spectra of a few objects in dense clouds may be due to PAHs. It is now thought that aromatic molecules in which N atoms are substituted for a few of the C atoms in a PAH's hexagonal skeletal network (PANHs) may well be as abundant and ubiquitous throughout the interstellar medium as PAHs. Spaceborne observations in the 5 to 8 um region, the region in which PAH spectroscopy is rich, reveal unidentified new bands and significant variation from object to object. It is not possible to analyze these observations because lab spectra of PANHs and PAHs condensed in realistic interstellar ice analogs are lacking. This lab data is necessary to interpret observations because, in ice mantles, the surrounding molecules affect PANH and PAH IR band positions, widths, profiles, and intrinsic strengths. Further, PAHs (and PANHs?) are readily ionized in pure H2O ice, further altering the spectrum. This proposal starts to address this situation by studying the IR spectra of PANHs frozen in laboratory ice analogs that reflect the composition of the interstellar ices observed in dense clouds. Thanks to Spitzer Cycle-4 support, we are now measuring the spectra of PAHs in interstellar ice analogs to provide laboratory spectra that can be used to interpret IR observations. Here we propose to extend this work to PANHs. We will measure the spectra of these interstellar ice analogs containing PANHs before and after ionization and determine the band strengths of neutral and ionized PANHs in these ices. This will enable a quantitative assessment of the role that PANHs can play in the 5-8 um spectrum of dense clouds and address the following two fundamental questions associated with dense cloud spectroscopy and chemistry: 1- Can PANHs be detected in dense clouds? 2- Are PANH ions components of interstellar ice?

Spitzer Space Telescope - General Observer Proposal #20159

Grain Composition in the Southern Coalsack

Principal Investigator: B-G Andersson
Institution: The Johns Hopkins University

Technical Contact: B-G Andersson, The Johns Hopkins University

Co-Investigators:
Peter G. Wannier, Jet Propulsion Laboratory
Stephan R. McCandliss, The Johns Hopkins University

Science Category: ISM
Observing Modes: IrsStare
Hours Approved: 7.1

Abstract:
We propose to use the Spitzer IRS SL1 & SL2 spectrographs to observe the solid state features due to carbonaceous/PAH and silicate grains in absorption towards four stars behind the Southern Coalsack dark cloud. Our goal is to determine the composition of the small grains, by contrasting sightlines, in the same cloud, showing nominal and enhanced grain destruction. Combined optical and NIR photometry shows distinct values of the total to selective extinction (R_V) for different parts of the cloud, indicating varying grain size distributions. Together with optical, FUV and X-ray observations, the R_V measurements indicate that shock-induced grain destruction is taking place in parts of the Coalsack. By comparing the dust absorption on sightlines with and without enhanced grain destruction, and by combining these with tracers of the gas phase abundance, we can determine the composition of the small grains. The target stars have been chosen because: 1) they have well determined distances, 2) they probe only absorption by Coalsack material, 3) they have FUSE and HST/STIS (or IUE) UV and FUV data already in hand to provide gas phase abundances and extinction curves and 4) they provide two examples each of sightlines with enhanced and nominal R_V.

Spitzer Space Telescope - General Observer Proposal #3416

Shock Dissipation in Nearby Star Forming Regions

Principal Investigator: John Bally
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Co-Investigators:
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Dirk Froebrich, Dublin Institute for Advanced Studies
Michael Smith, Armagh Observatory

Science Category: ISM
Observing Modes: IrsMap
Hours Approved: 10.0

Abstract:
We propose to probe the line emission from nearby star forming regions in the 5 to 37 micron spectral range using the slit-scan mode of IRS. Our goals are: [1] Measure the fluxes produced by the pure rotational lines of molecular hydrogen and other spectral features in the 5 to 38 micrometer region from the surroundings of 4 well-studied and nearby outflow sources. [2] Trace the intermediate velocity (2 to 30 km/sec) shocks in outflow regions. Such emission is predicted by models in which high velocity motions traced by optical and near-IR emission lines (Herbig-Haro objects) accelerate molecular outflows and degrade into turbulent motions. We will obtain slit-scan maps in the LL and SL modes of IRS of arc-minute scale regions surrounding HH 211, HH212, L1448c and, NGC 2071. By observing these four sources, we will compare the mid-IR emission lines produced by regions supporting various levels of star formation activity ranging from the birth of isolated single stars, to small groups, to rich clusters containing over 100 YSOs and stars as massive as 8 to 10 Solar masses.

Spitzer Space Telescope - General Observer Proposal #20378

Molecular Hydrogen As a Probe of Warm Interstellar Gas on Parsec Scales

Principal Investigator: Edwin Bergin
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Co-Investigators:
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Karen Willacy, Jet Propulsion Laboratory

Science Category: ISM
Observing Modes: IrsMap
Hours Approved: 97.7

Abstract:
We propose to use the Spitzer IRS spectrograph to conduct an unbiased study of emission from the pure rotational transitions of H2, S(0)-S(7), over parsec-sized scales in two clouds where star clusters are forming: NGC1333 and OMC-2. We will obtain 5 - 37 micron spectroscopic maps with high spatial resolution (3 - 11") and sensitivity over a 6' x 10' region in both sources, encompassing a least a dozen known outflows in each. This database will enable several scientific goals that cannot be met using any other instrument in the foreseeable future: (1) to search, using an unbiased survey, for an intermediate-temperature shocked component that would be unprobed by typical ground based tracers; (2) to derive a thermal map of the dominant gas component; (3) to use the H2 ortho-to-para ratio as an archeological probe of the thermal history of gas on parsec scales; (4) to characterize chemical changes in the shocked material, including the creation of gaseous H2O and CO2; and (5) to produce an unparalleled dataset that will test models of warm shocked gas, comparing the spatial distribution of the atomic tracers of dissociative shocks ([Fe II], [S I], [Si II]) with that of the molecular tracers of non-dissociative shocks (H2, H2O). We will interpret these spectroscopic maps using state-of-the-art chemical and physical models to significantly advance our understanding of shock physics and chemistry, to elucidate the interaction of outflows with the surrounding gas, and to produce an important Spitzer legacy to interstellar medium science.

Spitzer Space Telescope - Theoretical Research Proposal #30331

Theoretical Studies of Ice Formation in the Dynamic Interstellar Medium

Principal Investigator: Edwin Bergin
Institution: University of Michigan

Technical Contact: Edwin Bergin, University of Michigan

Co-Investigators:
Eric Herbst, The Ohio State University

Science Category: ISM
Dollars Approved: 90805.0

Abstract:
A part of the Spitzer legacy to interstellar medium (ISM) science will be a significant contribution to the characterization of molecular ices. Within our galaxy ice absorption features are detected by Spitzer towards every embedded protostar, stars that lie behind molecular clouds, and in absorption against the galactic infrared background. Numerous studies have focused on the carbon dioixide (CO2) molecule as the detection of its vibrational models requires space-borne platforms. Analysis of Spitzer data is providing clues to the origin of molecular ices and CO2 in particular. This has implications beyond chemistry in the ISM as interstellar and cometary ices show striking similarities in composition. However, there is little effort being placed on a theoretical underpinning of how the ice forms. We propose to take theoretical studies of ice formation, with an emphasis on CO2, in new directions by coupling recent dynamical models of molecular cloud formation to state-of-the-art gas and surface chemistry networks. In this fashion, we will constrain which ices form in abundance as low density gas condenses to form molecular clouds, thereby setting the initial chemical conditions for cloud fragmentation and star formation.

Spitzer Space Telescope - General Observer Proposal #50129

Searching for the Missing Sulfur in the Dense ISM

Principal Investigator: Edwin Bergin
Institution: University of Michigan

Technical Contact: Edwin Bergin, University of Michigan

Co-Investigators:
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Valentine Wakelam, Bordeaux Observatory

Science Category: ISM
Observing Modes: IrsMap
Hours Approved: 17.3

Abstract:
Sulfur-bearing molecules are widely used astrophysical probes in star-forming regions tracing the physical properties (density, temperature, kinematics) and the chemistry of the gas. However, observations of sulfur-bearing molecules in dense cores find a total abundance that is only a small fraction (~0.1%) of the sulfur seen towards diffuse regions. Thus, unlike all other major atomic species (hydrogen, oxygen, carbon, nitrogen) to this day we still do not know what species is the major reservoir of sulfur in the dense ISM. This has significant implications on our ability to reliably use these molecules as probes. Recent observations using the IRS instrument on Spitzer have potentially discovered the missing sulfur in atomic form lighting up at 25.2 microns within non-dissociative shocks in close proximity to 2 of youngest protostars (Class 0 objects). We propose here to survey additional Class 0 objects to determine if this result is peculiar to these objects or whether we have indeed found the primary reservoir of sulfur in dense interstellar gas. We will also explore the implications of these results on chemical theory using state-of-the-art chemical models. These observations will be a Spitzer legacy to ISM science and will offer the opportunity in the future to use S I emission as a probe of dense gas physics when its higher lying transition can be accessed by future observatories such as SOFIA.

Spitzer Space Telescope - General Observer Proposal #20604

Molecular Composition and Chemistry of Isolated Dense Cores

Principal Investigator: Adwin Boogert
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Co-Investigators:
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Science Category: ISM
Observing Modes: IrsMap IrsStare
Hours Approved: 29.2

Abstract:
The composition of molecular clouds and the envelopes and disks surrounding low mass protostars within them is still poorly known. There is little doubt that a large fraction of the molecules is frozen on grains, but the abundance of several crucial species (e.g. NH3, CH3OH, ions) in the ices is still highly uncertain. In addition, prominent spectral features discovered decades ago are still not securely identified (e.g. the 6.85 micron absorption band). Gas phase and grain surface chemistry play pivotal roles in molecule formation, but numerous other processes could have significant impacts as well: shocks, thermal heating, irradiation of ices by ultraviolet photons and cosmic rays. Complex species could be formed this way, profoundly influencing cloud, disk, and planetary/cometary chemistry. We propose to obtain Spitzer/IRS spectra of an unprecedented sample of sight-lines tracing dense isolated cores. These cores physically differ from the large, cluster-forming molecular clouds (Ophiuchus, Perseus) that are commonly studied: they are less turbulent, colder, less dense, and likely longer lived. These IRS spectra of isolated cores will thus provide unique information on the ice formation and destruction mechanisms. For example, the longer survival time of ices in these cores might promote the energetic formation of more complex species. Variations in the 6.85 um absorption band may elucidate its carrier. The CO2 band will reflect variations in H and O chemistry as well as thermal history. In an unbiased sample of 66 isolated cores imaged with IRAC/MIPS by the "c2d" Legacy program, we found 30 mostly new protostars. Toward the same cores we selected 33 highly extincted background stars as well, tracing the quiescent cloud medium against which the (processed?) ices around protostars can be contrasted. With this unique source sample it is possible to address the most fundamental questions in astrochemistry: what is the composition of the interstellar medium and how are complex molecules formed?

Spitzer Space Telescope - General Observer Proposal #50698

SN 185 and its Remnant RCW 86: A Type Ia Explosion within a Bubble?

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Co-Investigators:
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Science Category: ISM
Observing Modes: IracMap IrsMap MipsScan
Hours Approved: 15.4

Abstract:
The bright guest star of AD185 is the earliest recorded historical supernova (SN), but its remnant has only recently been firmly identified with RCW 86 with help of X-rays and very high energy (VHE) Gamma-rays. RCW 86 is unlike any other historical SN, implicating a Type Ia explosion within a wind-blown bubble. X-ray synchrotron emission and VHE Gamma-rays are produced by relativistic particles accelerated in fast (several thousand km/s) shocks that are present in RCW 86, while slower radiative and nonradiative shocks are driven into the dusty shell swept up by the SN progenitor. We propose Spitzer observations of RCW 86, that will allow us to determine dust properties and physical conditions within both slow and fast shocks. We will determine shock densities in the whole remnant using MIPS imaging at 24 and 70 microns. This will allow us to finally determine whether VHE emission arises from relativistic electrons or from cosmic ray protons accelerated by the SN shock. We will also determine how acceleration of synchrotron-emitting electrons to TeV energies depends on the shock density. We propose IRS spectral mapping in two very different regions of the remnant to perform a more detailed and sensitive study of dust emission and dust destruction under differing plasma conditions, and of line emission produced by radiative shocks. This will also verify the results of the imaging observations, and will allow for quantitative comparison with models for dust emission and destruction in SN shocks. We request imaging with IRAC in the brightest region of the remnant to map emission from the hottest, transiently heated small grains, and to determine their destruction rates. Physical properties and dust content within the shell swept up by the RCW 86 progenitor will help us to constrain the pre-SN evolution of a Type Ia progenitor, a significant step toward understanding of progenitors of thermonuclear explosions.

Spitzer Space Telescope - General Observer Proposal #20125

Evaporating Grains in Reflection Nebulae?

Principal Investigator: Jesse Bregman
Institution: NASA Ames Research Center

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Co-Investigators:
Pasquale Temi, SETI Institute

Science Category: ISM
Observing Modes: IrsStare
Hours Approved: 12.7

Abstract:
ISOCAM spectral data of Ced 201 indicate that there is a component underlying the PAH bands that Cesarsky et al. (2000) have attributed to emission from very small carbonaceous grains (VSGs). These grains would not be the classical small silicate grains observed in the interstellar medium and HII regions, but amorphous carbon particles or PAH clusters that could comprise the smallest of the interstellar dust grains. Very small carbonaceous grains with some aromaticity have been suggested as contributors to the interstellar extinction curve, but have never been directly confirmed. Cesarsky et al. also suggest that close to the exciting star of the nebula, PAH molecules are either liberated from the VSGs, or the VSGs are aromaticized by the UV from the central star. Their observations show that the 7.7 band appears to get broader towards the edges of the nebula, as expected if the PAHs are in clusters, but the ISOCAM data do not have sufficient spectral resolution (about 40) to determine if the apparent broadening is due to multiple components or true broadening of the feature. We propose to study the emission as a function of position in Ced 201 and two other morphologically similar reflection nebulae at the higher spectral resolution of the Spitzer IRS and at longer wavelengths than was possible with ISOCAM to determine: 1. whether the apparent broadening of the 7.7 micron band is due to intrinsic broadening or to separate components that vary in relative strength as a function of distance from the star. 2. whether the other PAH emission bands, particularly the 11.3 micron band, broaden as well, as expected if the PAHs exist as clusters or VSGs. 3. whether the temperature of the continuum decreases with distance from the star (as for classical VSGs), maintains a constant value as for grains small enough to see just single photon events, or whether it is a combination of the two. 4. if VSGs are present, the size of the VSGs required to produce the observed continuum.

Spitzer Space Telescope - General Observer Proposal #20311

PAHs in the Diffuse ISM

Principal Investigator: Jesse Bregman
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Alexander Tielens, University of Groningen

Science Category: ISM
Observing Modes: IrsStare
Hours Approved: 16.4

Abstract:
Our understanding of the IR emission features and their carriers (PAHs) is almost exclusively based upon spectral studies of bright HII regions and planetary nebulae. In contrast, while PAHs spend most of their lives cycling between the diffuse ISM and dark clouds, very little is known about the comparatively weak IR emission spectrum of the diffuse ISM. One of the major discoveries of IRAS was the widespread presence of cirrus emission at mid-IR wavelengths throughout the diffuse ISM, but IRAS was unable to characterize this emission further, and more recent studies using the IRTS and ISOPHOT did not produce spectra of sufficient quality for meaningful comparisons with other types of sources (Onaka et al. 1996; Mattila et al. 1996). We propose to measure the IR emission spectrum of the diffuse ISM along well studied lines of sight towards diffuse translucent clouds, of bright cirrus clumps, and of reflection nebulae. This will provide a census of low to mid density and UV field intensities that can be compared to existing Spitzer/ISO data of regions with high density and high UV field intensity (i.e. HII regions and planetary nebulae). The questions we will address are: 1. What is the mid-IR spectrum of the diffuse ISM? 2. How does the spectrum of the mid-IR emission spectrum depend on the local physical conditions (density, UV field) ? 3. How do the spectra of the diffuse ISM (low density, low UV field) compare to the spectra of reflection nebulae (intermediate conditions) and to those of HII regions and reflection nebulae (high density, high UV field)? The proposed observations will provide direct information on the abundance and ionization state of PAHs in the diffuse ISM.

Spitzer Space Telescope - Legacy General Observer Proposal #30594

MIPSGAL II: Surveying the innermost part of the Galactic plane at 24 and 70 microns with MIPS

Principal Investigator: Sean Carey
Institution: SSC

Technical Contact: Sean Carey, SSC

Co-Investigators:
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Kathleen Kraemer, Air Force Research Laboratory
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Peter Martin, CITA
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Francois Boulanger, IAS-Universite Paris-Sud
Marc-Antoine Miville-Deschenes, CITA/University of Toronto
Luisa Rebull, Spitzer Science Center
Roberta Paladini, Spitzer Science Center
Russ Shipman, SRON

Science Category: ISM
Observing Modes: MipsScan
Hours Approved: 158.0

Abstract:
We propose a 72 square degree survey of the innermost Galactic disk (abs(l) <10, up to (abs(b) <3) at 24 and 70 microns with MIPS. These observations will connect the two fields observed by MIPSGAL and are complementary to the GLIMPSE II and proposed GLIMPSE 3D surveys. This data will finish the census of massive star formation inside the molecular ring, provide detailed information on the distribution and energetics of small dust grains toward the nucleus of our Galaxy, and identify all massive evolved stars in the surveyed portion of the Galactic bulge. The data will be processed with the MIPSGAL pipeline which significantly reduces artifacts caused by the bright backgrounds and sources in the Galactic plane. As a legacy program, we are waiving the proprietary rights to the data and plan to distribute enhanced data products such as image mosaics and source catalogs.

Spitzer Space Telescope - Theoretical Research Proposal #40739

Theoretical Models of Interstellar Ice Evolution

Principal Investigator: Steven Charnley
Institution: SETI Institute

Technical Contact: Steven Charnley, SETI Institute

Co-Investigators:
Steve Rodgers, SETI Institute
Jean Chiar, SETI Institute
Perry Gerakines, University of Alabama

Science Category: ISM
Dollars Approved: 80388.0

Abstract:
Using a new stochastic gas-grain chemistry model, we will construct theoretical models of ice evolution as interstellar material evolves from quiescent media to the dense environment surrounding a protostar. We will use the predicted grain mantle composition and layering at different epochs to compute synthetic ice absorption spectra. The ability to understand the chemical composition and relative ages of solid material in various lines of sight will inform the analysis and interpretation of data returned from the Spitzer Space Telescope. We also propose to make a well-documented version of this simulation code widely available through a website. We will provide the necessary theoretical and computational background so that other astronomers will be able to implement the code in analyzing their data.

Spitzer Space Telescope - General Observer Proposal #3616

Solving the Mysteries of Interstellar Dust Composition in the Milky Way

Principal Investigator: Jean Chiar
Institution: SETI Institute

Technical Contact: Jean Chiar, SETI Institute

Co-Investigators:
Michael Egan, MDA/AS
Alexander Tielens, Kapteyn Institute/SRON
G.C. Sloan, Cornell University

Science Category: ISM
Observing Modes: IrsStare
Hours Approved: 16.3

Abstract:
Interstellar dust is ubiquitous, yet its precise composition is still widely debated. Spitzer's Infrared Spectrometer provides the sensitivity to study previously unattainable lines of sight throughout the plane of the Milky Way. In this proposal, we seek to study the hydrocarbon and silicate dust components of the interstellar medium for 56 lines of sight spanning visual extinctions from 6.6 to 32.2 magnitudes across a range of Galactic longitudes and latitudes. Specifically, we will measure the hydrocarbon absorption features at 6.9 and 7.3 micron, and the silicate absorption features at 9.7 and 18.5 micron. The ratio of the hydrocarbon and silicate features provides a direct handle on the hydrocarbon to silicate dust volume. It has been previously been noted that the optical depth to visual extinction ratio is distinct for lines of sight within the Solar neighborhood compared to the Galactic Center. Thus, these features will also be related to their visual extinction and Galactic location to test whether location has an effect on the optical depth to Av ratio. Finally, the silicate mineralogy can be assessed by studying the ratio of the 9.7 to 18.5 micron absorption features, whose relative strengths have been shown to be indicative of olivine-rich or pyroxene-rich silicates. In order to obtain sufficient sampling of both Galactic location and visual extinction, we will observe 56 lines of sight requiring a total of 16.3 hours.

Spitzer Space Telescope - General Observer Proposal #50363

Probing the Onset of Dust Coagulation in Dense Clouds

Principal Investigator: Jean Chiar
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Co-Investigators:
Douglas Whittet, Rensselaer Polytechnic Institute
Laurens Waters, U. Amsterdam, Netherlands
Alexander Tielens, NASA Ames Research Center
Carlos Roman-Zuniga, Harvard CfA
Yvonne Pendleton, NASA HQ
Michiel Min, U. Amsterdam, Netherlands
Charles Lada, Harvard CfA
Johanna van Breemen, U. Amsterdam, Netharlands
Achim Tappe, Harvard CfA

Science Category: ISM
Observing Modes: IrsStare
Hours Approved: 10.2

Abstract:
Our previous Spitzer IRS observations have confirmed the striking break-down of the diffuse ISM linear correlation of the depth of the 9.7 mic silicate absorption feature (tau(9.7)) with near-IR color excess (E(J-Ks)) at high extinctions in dense clouds. In addition, the observed shape of the 9.7 mic band changes between dense clouds and the diffuse ISM. Theoretically, these variations have been attributed to the effect of grain growth by coagulation on the extinction properties of interstellar dust, but the conditions responsible for grain coagulation in dense clouds is not well understood. The new observations we propose here in combination with already existing deep IR extinction maps, provide us with a new and unique opportunity to directly probe the onset of dust coagulation and the change in the physical properties of the dust in the environment of a single nearby dense cloud: the Pipe Nebula. The goals of our proposal are: - We will measure the change in tau(9.7) as a function of near-IR extinction and density in dense cloud cores and the surrounding lower-density intercore material. - We will analyze the 9.7 mic profile shape, to observationally determine under what conditions deviations from the diffuse ISM feature become apparent. - We will establish, observationally, the interrelationship between the flattening of the tau(9.7)/E(J-Ks) relation and the change in shape of the silicate profile. Our lines of sight span a wide range of accurately determined (IR) extinctions (Av ~ 5 to 48 mag). We will accomplish our above goals by obtaining high S/N IRS observations of a well-chosen sample of background stars behind the Pipe Nebula and two of its most opaque dense cores. The source list ensures that the extinction range is well-sampled spatially and in terms of extinction value inside the cloud cores and the surrounding intercore material. In this way, we will be able to observe changes in the dust properties as they occur within a single dense cloud.

Spitzer Space Telescope - General Observer Proposal #50267

Characterizing the Dust-Correlated Anomalous Emission in LDN 1622

Principal Investigator: Kieran Cleary
Institution: Jet Propulsion Laboratory

Technical Contact: Kieran Cleary, Jet Propulsion Laboratory

Co-Investigators:
Clive Dickinson, California Institute of Technology
Simon Casassus, Universidad de Chile
Itsuki Sakon, University of Tokyo
Charles Lawrence, Jet Propulsion Laboratory

Science Category: ISM
Observing Modes: IrsMap IrsStare
Hours Approved: 11.1

Abstract:
The search for "dust-correlated microwave emission" was started by the surprising excess correlation of COBE-DMR maps, at 31.5, 53 and 91GHz, with DIRBE dust emission at 140 microns. It was first thought to be Galactic free-free emission from the Warm Ionized Medium (WIM). However, Leitch et al. (1997) ruled out a link with free-free by comparing with Halpha templates and first confirmed the anomalous nature of this emission. Since then, this emission has been detected by a number of experiments in the frequency range 5-60 GHz. The most popular explanation is emission from ultra-small spinning dust grains (first postulated by Erickson, 1957), which is expected to have a spectrum that is highly peaked at about 20 GHz. Spinning dust models appear to be broadly consistent with microwave data at high latitudes, but the data have not been conclusive, mainly due to the difficulty of foreground separation in CMB data. LDN 1622 is a dark cloud that lies within the Orion East molecular cloud at a distance of 120 pc. Recent cm-wave observations, in combination with WMAP data, have verified the detection of anomalous dust-correlated emission in LDN 1622. This mid-IR-cm correlation in LDN 1622 is currently the only observational evidence that very small grains VSG emit at GHz frequencies. We propose a programme of spectroscopic observations of LDN 1622 with Spitzer IRS to address the following questions: (i) Are the IRAS 12 and 25 microns bands tracing VSG emission in LDN 1622? (ii) What Mid-IR features and continuum bands best correlate with the cm-wave emission? and (iii) How do the dust properties vary with the cm-wave emission? These questions have important implications for high-sensitivity CMB experiments.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #120

Study of new 16.4 micron PAH feature

Principal Investigator: Dale Cruikshank
Institution: NASA-Ames

Technical Contact: Kris Sellgren, Ohio State University

Science Category: ISM
Observing Modes: IrsStare
Hours Approved: 1.7

Abstract:
These are four sources to be added to Cruikshank's existing program on the study of a new 16.4 micron PAH feature.

Spitzer Space Telescope - General Observer Proposal #40183

Probing the IR Cirrus: Small-Scale Structure and Molecular Content

Principal Investigator: Charles Danforth
Institution: University of Colorado

Technical Contact: Charles Danforth, University of Colorado

Co-Investigators:
J. Michael Shull, U. Colorado
Felix J Lockman, NRAO Greenbank

Science Category: ISM
Observing Modes: IracMap MipsScan
Hours Approved: 16.5

Abstract:
The infrared cirrus is a network of diffuse interstellar clouds seen over ~50% of the sky at high Galactic latitudes. The cirrus has not yet been studied by Spitzer, yet there are several compelling scientific reasons to do so. First, the cirrus appears to contain a substantial amount of molecular hydrogen. A correlation is seen to exist between the column density of H2 seen in absorption toward extragalactic sight lines and the 100um cirrus emission adjacent to those sight lines. However, the low spatial resolution of existing all-sky IR maps and likely variation of cirrus structure on angular scales >5' introduces a great deal of scatter into the correlation. Using cirrus flux as a proxy for H2 column density will allow us to correct large-scale HI surveys for the "missing" molecular contribution and get accurate measurements of the total mass in this diffuse ISM phase. Second, the cirrus may delineate the disk-halo interface and be a site of enhanced cooling (via H2 rotational excitation) and triggered star formation. Detailed studies of cirrus morphology at small scales (<1') can tell us a great deal about the physical structure of the cirrus: thickness, particle density, and cooling rates. Additionally, small-scale cirrus structure is a significant Galactic foreground that needs to be understood and characterized for future cosmology probes such as Planck and ALMA. We propose a set of Spitzer observations of seven high-latitude fields around AGN to address these two science drivers. MIPS observations at 70 and 160um will map the cirrus at unprecedented resolution while 24um and IRAC 8um fields will map the brightest dust and PAH emission.

Spitzer Space Telescope - General Observer Proposal #50639

Imaging the IR Cirrus: Molecular Content & Small-Scale Structure

Principal Investigator: Charles Danforth
Institution: University of Colorado

Technical Contact: Charles Danforth, University of Colorado

Co-Investigators:
J. Michael Shull, University of Colorado
F. Jay Lockman, NRAO Green Bank

Science Category: ISM
Observing Modes: MipsScan
Hours Approved: 22.7

Abstract:
The infrared cirrus is a network of diffuse interstellar clouds seen over ~50% of the sky at high Galactic latitudes. There are several compelling scientific reasons to study the cirrus with Spitzer. First, the cirrus appears to contain a substantial amount of molecular hydrogen. A correlation exists between the column density of H2 seen in absorption along extragalactic sight lines and the 100um cirrus emission adjacent to those sight lines. However, the low spatial resolution of existing all-sky IR maps and patchy nature of cirrus emission on angular scales >5' introduces a great deal of scatter into the correlation. Using cirrus flux as a proxy for H2 column density will allow us to correct large-scale HI surveys for the "missing" molecular contribution and get accurate measurements of the total mass in this diffuse ISM phase. Second, the cirrus may delineate the disk-halo interface and be a site of enhanced cooling via H2 rotational excitation and triggered star formation. Detailed studies of cirrus morphology at small scales (<5') can tell us a great deal about the physical structure of the cirrus: thickness, particle density, and cooling rates. Additionally, small-scale cirrus structure is a significant Galactic foreground that needs to be understood and characterized for future cosmology probes such as Planck and ALMA. A small program of Spitzer observations during Cycle 4 is being carried out utilizing deep MIPS observations at 70 and 160um to map the cirrus. IRAC 8um observations trace emission from PAH molecules and small grains. In our first observation (PKS0405-12) we see cirrus emission at 8um, 70um, and 160um with clear structure down to the instrumental resolution. The cirrus intensity along the H2 absorption sight line is seen to be lower than in the low-resolution data. We propose a set of follow-on observations of eight fields. These fields have been chosen to refine the IR-H2 correlation and will additionally address the small-scale structure science driver.

Spitzer Space Telescope - General Observer Proposal #3336

Mapping ices in a dense cloud toward background stars: Tracers of solid state chemistry at high spatial resolution

Principal Investigator: Emmanuel Dartois
Institution: Universite Paris Sud

Technical Contact: Klaus Pontoppidan, California Institute of Technology

Co-Investigators:
Klaus Pontoppidan, Leiden Observatory
Guillermo Munoz Caro, IAS
Louis d'Hendecourt, IAS
Ewine van Dishoeck, Leiden Observatory
Jes Joergensen, Leiden Observatory
Francois Boulanger, IAS

Science Category: ISM
Observing Modes: IrsStare
Hours Approved: 15.6

Abstract:
We propose to obtain spatially well resolved maps of ice abundances in two isolated dark cloud cores using absorption spectroscopy. The large wavelength coverage together with the unpredented sensitivity of Spitzer-IRS will allow us to obtain absorption spectra of many different ice species toward faint background stars. We will thereby map the detailed ice abundance structure of the clouds in molecules such as H2O, CO2, CH3OH, CH4 and NH3. This unique approach will make it possible to address the onset of formation of each individual ice species as a function of local physical conditions such as density, extinction and temperature. Of special interest is to constrain the chemical interrelation between the ice constituents. We propose to map ice abundances in the starless Coalsack cloud core and in the isolated core L723, which contains a deeply embedded protostar. Spitzer-IRS is able to record the spectra of background sources with a spatial density of better than one source per square arcminute, which is two orders of magnitude higher than previously attained. This density of lines of sight is sufficient to adequately sample a typical 5'x5' dark cloud.

Spitzer Space Telescope - General Observer Proposal #20294

Measuring the Veil: The Galactic Extinction From 3 to 30 Microns - The Dense AND Diffuse ISM -

Principal Investigator: C. Dudley
Institution: Naval Reseach Laboratory

Technical Contact: C. Dudley, Naval Reseach Laboratory

Co-Investigators:
H. Smith, CfA
A. Tokunanga, IfA
S. Satyapal, George Mason University
J. Fischer, NRL
E. Dwek, GSFC

Science Category: ISM
Observing Modes: IrsStare
Hours Approved: 5.3

Abstract:
Although the Galactic infrared extinction curve is quite uncertain at wavelengths longer than 2 micron, the infrared extinction is critical to the interpretation of infrared observations. Here we propose to measure the 3--30 micron extinction curve on 4 lines of sight towards background stars with a range of visual extinction between 13 and 70 mag. These high extinctions are required to allow a precise measurement at infrared wavelengths where extinction is much less. We will use the traditional (in the optical) method of ratioing the Spitzer IRS low resolution spectra of extinguished and unextinguished stars. Our extinguished sources have been chosen to be free of photospheric spectral features and most importantly (for the infrared) free of circumstellar dust emission. We take the additional step of observing a range of calibrator spectral types to account for the unlikely possibility that a Rayleigh-Jeans treatment would be inadequate. Our sight line selection will allow us to measure separately extinction due to dust and/or ice in both dense and diffuse ISM environments and will provide for the first time a truly reliable measure of the ratio of the strengths of the ten and twenty silicate silicate features in these distinct environments. 5.3 hours is requested to complete these observations.

Spitzer Space Telescope - General Observer Proposal #50270

Grain Destruction in Puppis A

Principal Investigator: Eli Dwek
Institution: NASA Goddard Space Flight Center

Technical Contact: Eli Dwek, NASA Goddard Space Flight Center

Co-Investigators:
Richard G. Arendt, CRESST/UMBC/GSFC
William Blair, Johns Hopkins University
Parviz Ghavamian, Johns Hopkins University
Una Hwang, Johns Hopkins U/GSFC
Knox Long, STScI
Robert Petre, NASA/GSFC
Jeonghee Rho, Spitzer Sci Ctr/Caltech
Frank Winkler, Middlebury College

Science Category: ISM
Observing Modes: IracMap IrsMap IrsStare MipsScan
Hours Approved: 15.2

Abstract:
We propose to use the supernova remnant Puppis A as an interstellar laboratory for studying the effects of shocks on dust grains. Puppis A is a well-resolved, bright infrared source with strongly correlated IR/X-ray emissions that are shaped by strong interactions of the remnant shock with an environment that includes a CO a nd HI cloud complex. It contains a wide range of plasma conditions that would allow study of the effects of shocks on the processing and destruction of dust grains under a variety of conditions. A Spitzer study of Puppis A is further supported by the broad range of exquisite complementary observations at X-ray and UV wavelengths. All this makes Puppis A the ideal target for the study of shocks on dust. Determining the efficiency of the various grain destruction processes is of great astrophysical importance since they play a major role in our understanding of the sources and origin of interstellar dust. For example, the origin of the large amount of dust in high-redshift galaxies is a question of great astrophysical importance. Since AGB stars did not have time to evolve off the main sequence, supernovae are the only source of newly-formed dust in these young galaxies. If grains were not destroyed, supernovae may have been able to produce the observed amount of dust, assuming a condensation efficiency of about unity in their ejecta. However, if grain destruction is taken into account, then only accretion onto preexisting grain in molecular clouds can account for the observed mass of dust in the high-redshift (z > 6) universe. Determining the grain destruction efficiency is therefore a major issue in astrophysics, with local as well as cosmological implications. The proposed Spitzer observations of Puppis A are key for addressing this issue.

Spitzer Space Telescope - General Observer Proposal #50490

Warm H2 trails in molecular clouds: a close view at turbulence dissipation

Principal Investigator: Edith Falgarone
Institution: Ecole Normale Superieure

Technical Contact: Edith Falgarone, Ecole Normale Superieure

Co-Investigators:
Francois Boulanger, IAS, Orsay
Benjamin Godard, LRA, ENS
Pierre Hily-Blant, LAOG, Grenoble
Guillaume Pineau des Forets, IAS, Orsay
Laurent Verstraete, IAS, Orsay
Mark Wolfire, Univ. of Maryland, Dept Astron.

Science Category: ISM
Observing Modes: IrsMap
Hours Approved: 7.1

Abstract:
Unlike stars and many plasmas in the universe, gas in molecular clouds is a highly dissipative system. It is this property that allows turbulent clouds to form stars. Little is known on the detailed processes leading to turbulent dissipation. Where, how and at what rate does molecular cloud turbulence dissipate? The current paradigm is that it occurs fast, in shocks. But turbulent dissipation in clouds is mild, intermittent in space and time, and shear-layers also contribute. A statistical analysis of the velocity field of a large CO map in the Polaris molecular cloud, has allowed us to disclose a spectacular structure of large velocity-shear, extending over more than a parsec in the environment of two low-mass dense cores. We show that 25% of the turbulent energy in the field is dissipated in the 2.5% area where the shear is the largest. We show why the bulk of the dissipated energy is expected to be radiated in the pure rotational lines of H2 and rely on former detections of high HCO+ abundances in this structure to compute the expected H2 line intensity. We propose Spitzer IRS observations of the H2 pure rotational lines in that structure to test these theoretical expectations and the role of shear-layers in contributing to the turbulent dissipation. The Spitzer-IRS is ideally suited to this experiment since high sensitivity and spatial resolution at the arcsec scale are required and the IRS wavelength range covers the dominant cooling lines of the dissipation.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #27

CO2 Ice Absorption in the Interstellar Medium

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Edwin Bergin, University of Michigan

Science Category: ISM
Observing Modes: IrsStare
Hours Approved: 3.2

Abstract:
We will use the IRS to observe several lines of sight in the Taurus Molecular Cloud to search for the 15.2 micron absorption feature due to CO2 ice. The survey samples a variety of lines of sight towards embedded objects and field stars, probing gas with both high and low extinction. These observations will be used to examine the uncertain formation pathways of CO2 ice in the interstellar medium.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #28

Spectral Line Diagnostics of Shocks and Photon-Dominated Regions

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: David Neufeld, The Johns Hopkins University

Science Category: ISM
Observing Modes: IrsMap
Hours Approved: 6.7

Abstract:
We will use the step-and-stare mode of IRS to observe the sources S140, NGC 7023, and HH54, obtaining spectral line maps of regions of size ~ 55 x 55 arcsec (45 x 45 arcsec for HH54) using the Short-Lo, Short-Hi and Long-Hi modules. These observations will yield maps of the emission line intensities for several rotational transitions of H2 and H2O and many fine structure lines of atoms and atomic ions. The scientific goal is to study the spatial variation in gas temperature, density, H2 ortho-to-para ratio, water abundance and ionization conditions within the three sources studied, thereby enhancing our physical understanding of interstellar shock waves and photodissociation regions.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30790

B-Cirrus: Investigation of grain processing in moderate radiation fields

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Sean Carey, SSC

Co-Investigators:
Sean Carey, Caltech/SSC
Bill Glaccum, Caltech/SSC
Bill Reach, Caltech/SSC
Russ Shipman, Kapteyn Astronomical Institute/SRON

Science Category: ISM
Observing Modes: IracMap MipsPhot MipsScan
Hours Approved: 8.4

Abstract:
We propose IRAC and MIPS maps of infrared cirrus surrounding two embedded B stars, HR 5336 and HR 890. Previous IRAS investigations of these sources show that 12 and 25 micron emission is deficient relative to the 100 micron emission in the vicinity of the star. The mid-infrared emission deficits have been interpreted as destruction of the polycyclic aromatic hydrocarbons (PAHs) and very small grains (VSGs) responsible for the mid-infrared emission. The 25 micron emitters appear to be more depleted than the 12 micron emitters suggesting that VSGs are less robust than PAHs. The proposed observations will provide a high resolution, detailed study of the abundance of PAHs, VSGs and large grains as a function of distance from the embedded object and radiation field. The abundances will be compared to current generation grain models and will provide information on the processing of VSGs and PAHs in moderately enhanced radiation fields.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40031

Decoding the colors of the interstellar medium

Principal Investigator: Giovanni Fazio
Institution: Smithsonian Astrophysical Observatory

Technical Contact: William Reach, IPAC

Co-Investigators:
Joseph Hora, CfA
Margaret Meixner, STScI

Science Category: ISM
Observing Modes: IrsMap
Hours Approved: 15.0

Abstract:
The Infrared Array Camera is very sensitive to diffuse emission, and its multi-band architecture has enabled Legacy Surveys of the inner Galactic Plane (GLIMPSE+MIPSGAL) and the Large Magellanic Cloud (SAGE). Inspection of these large-scale imaging surveys reveals extended emission with distinct colors. The vast majority of diffuse emission has color characteristics of polycyclic aromatic hydrocarbons (PAH), with proportions in IRAC channels 1:2:3:4 of 4:6:35:100. As a key to decoding these colors we selected 10 lines of sight with distinct colors (7 in the Milky Way and three in the LMC) and propose to observe these fields using IRS to measure the diffuse emission.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50027

IRAC Imaging of Star-Cloud Collisions in the Pleiades

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: John Stauffer, Spitzer Science Center

Co-Investigators:
Luisa M. Rebull, SSC
Patrick Lowrance, SSC
Inseok Song, SSC

Science Category: ISM
Observing Modes: IracMap
Hours Approved: 1.2

Abstract:
The blue Palomar sky survey plate of the Pleiades region provides clear evidence that there is considerable dust close to the bright stars of the Pleiades. However, the network of dust filaments does not provide any unambiguous signpost for the kinematics of the dust (and gas). Radial velocity measures of interstellar absorption lines towards the bright Pleiades stars indicates that the gas is moving towards the Pleiades at a relative velocity of about 10 km/s, indicating that the gas/dust are not resident in the Pleiades but are instead transiting through the cluster. White & Bally (1993) concluded that the Pleiades was impacting the cloud from the East - and leaving a wake behind, visible in the IRAS 60 and 100 micron images of the region. Herbig & Simon (2001) imaged the brightest portion of the Merope nebula with HST, and concluded that the shape of the nebula could only be explained by the gas impacting the Pleiades from the south-southeast. Their conclusion was that the transiting cloud was an outlyer from the Taurus molecular cloud. The two explanations are not consistent. As part of a GTO program, we have obtained shallow IRAC imaging of the center of the Pleiades and have identified two stars which appear to be impacting cloud condensations at the current epoch, with extended circumstellar dust prominent at 8 um. An additional star with similar characteristics has been identified from FEPS data. A or F stars impacting moderate-density clouds should carve paraboloidal cavities in the cloud (Artymowicz and Clampin 1997), with the detailed shape of the cavity rim indicating the direction of relative motion of the star and gas. We propose deep IRAC imaging of the three stars impacting the passing cloud in order to define better the shape of their extended emission, and hence determine the motion of the gas and dust relative to the Pleiades stars.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50692

The Silicate-Extinction Relationship in Filament L673

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Tracy Huard, University of Maryland, College Park

Co-Investigators:
Tracy Huard, University of Maryland
Lori Allen, SAO
Klaus Pontoppidan, Caltech
Jeff Bary, University of Virginia
Jarron Leisenring, University of Virginia
Adwin Boogert, NASA Herschel Science Center
Claudia Knez, University of Maryland

Science Category: ISM
Observing Modes: IrsStare
Hours Approved: 6.4

Abstract:
We propose to obtain Spitzer IRS spectra of 18 background stars toward two cores within the isolated dense filament L673. These stars were carefully selected to probe a wide range of extinctions in the starless core L673-SMM4 and the cluster-forming core L673-SMM1/2 in order to further investigate the silicate-extinction relationship in dense, isolated environments. With the primary goal of characterizing this relationship in different core environments, a previous program (PID 40928) included 63 background stars sampling a wide range of extinctions through four cores: a starless core, single-star-forming core, cluster-forming core, and a core apparently exhibiting an anomalous relationship. The additional observations proposed here would serve to (1) provide a more robust characterization of differences between the silicate-extinction relationship in starless and star-forming cores, and (2) enable us to address whether this relationship is similar for cores of similar star-formation rates. We have shown previously that the silicate-extinction relationship is a sensitive probe of grain evolution, providing constraints on the carbon-to-silicate composition and grain sizes, especially when combined with 1-1000 micron observations.

Spitzer Space Telescope - Theoretical Research Proposal #20275

Unfolding the Information of the Interstellar H$_2$ Spectrum: Its impact on Spitzer IR Observations

Principal Investigator: Gary Ferland
Institution: University of Kentucky

Technical Contact: Gary Ferland, University of Kentucky

Co-Investigators:
Teck Ghee Lee, University of Kentucky and Oak Ridge National Lab
David R. Schultz, Oak Ridge National Lab
Phillip C. Stancil, University of Georgia

Science Category: ISM
Dollars Approved: 51444.0

Abstract:
Molecular hydrogen is the most ubiquitous molecule in the universe. H$_2$ plays a pivotal role in a variety of processes that significantly influence the chemical and physical state of interstellar gas. However, the lack of both accurate and complete collisional data sets for rovibrational inelastic cross sections and rate coefficients for H, He, and H$_2$ impacting the dominant molecular species (e.g. H$_2$, HD, and CO) has created a serious set back in the development of reliable astrophysical models complementing NASA's {it Spitzer} IR observations. It has been shown that the uncertainties in the existing collisional rate coefficient data can be significant. Modeling and interpretation of observations of such environments require quantitatively accurate and complete treatment of H$_2$. To derive significant scientific return from the unprecedented observations that are expected in the near future, we propose to compute rovibrational excitation and dissociation cross sections and rate coefficients for collisions of H, H$_2$ and He with H$_2$ and HD for all transitions between all bound rovibrational levels of the target molecules using continued development of well established quantum mechanical close-coupling and classical trajectory methods. Rate coefficients will be computed from 10 to 50,000~K and fit to convenient functional forms with physical low- and high-temperature limits. The results of this proposal will then enable models, such as the very widely used and tested spectral modeling code Cloudy, to reliably simulate these astrophysical environments, leading to deeper examination and understanding of their physical properties through {it Spitzer} observations of H$_2$ features.

Spitzer Space Telescope - General Observer Proposal #50516

The Eagle Nebula: a spectral template for star forming regions

Principal Investigator: Nicolas Flagey
Institution: Spitzer Science Center

Technical Contact: Nicolas Flagey, Spitzer Science Center

Co-Investigators:
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Mathieu Compiegne, CITA, University of Toronto
Eli Dwek, NASA Goddard Space Flight Center
Emilie Habart, Institut d'Astrophysique Spatiale
Remy Indebetouw, University of Viriginia
Thierry Montmerle, Laboratoire d'Astrophysique de Grenoble
Alberto Noriega-Crespo, Spitzer Science Center

Science Category: ISM
Observing Modes: IrsMap MipsSed
Hours Approved: 56.1

Abstract:
IRAC and MIPS have revealed spectacular images of massive star forming regions in the Galaxy. These vivid illustrations of the interaction between the stars, through their winds and radiation, and their environment, made of gas and dust, still needs to be explained. The large scale picture of layered shells of gas components, is affected by the small scale interaction of stars with the clumpy medium that surrounds them. To understand spatial variations of physical conditions and dust properties on small scales, spectroscopic imaging observations are required on a nearby object. The iconic Eagle Nebula (M16) is one of the nearest and most observed star forming region of our Galaxy and as such, is a well suited template to obtain this missing data set. We thus propose a complete spectral map of the Eagle Nebula (M16) with the IRS/Long Low module (15-38 microns) and MIPS/SED mode (55-95 microns). Analysis of the dust emission, spectral features and continuum, and of the H2 and fine-structure gas lines within our models will provide us with constraints on the physical conditions (gas ionization state, pressure, radiation field) and dust properties (temperature, size distribution) at each position within the nebula. Only such a spatially and spectrally complete map will allow us to characterize small scale structure and dust evolution within the global context and understand the impact of small scale structure on the evolution of dusty star forming regions. This project takes advantage of the unique ability of IRS at obtaining sensitive spectral maps covering large areas.

Spitzer Space Telescope - Theoretical Research Proposal #30063

Towards Complete Microphysical Modeling of Warm Interstellar Molecules: H2 Collisional Dissociation for Spitzer IR Observations

Principal Investigator: Robert Forrey
Institution: Penn State University

Technical Contact: Robert Forrey, Penn State University

Co-Investigators:
Balakrishnan Naduvalath, University of Nevada, Las Vegas
Phillip Stancil, University of Georgia
Teck Lee, University of Kentucky
Gary Ferland, University of Kentucky
David Schultz, Oak Ridge National Laboratory

Science Category: ISM
Dollars Approved: 50525.0

Abstract:
The role of molecules in a variety of interstellar environments, including photodissociation regions, star-forming regions, circumstellar shells, and other molecular regions, is far-reaching. Molecules are pivotal to determining the thermal and density structure of the gas and provide diagnostics through emission, absorption, and fluorescence. However, these environments are typically of low density, may be exposed to shocks, and are usually irradiated in the UV by nearby hot stars which results in significant departures from equilibrium for the chemical, ionization, and internal energy state of the gas. Therefore, to accurately model these environments, and thereby interpret results from Spitzer spectroscopic observing programs, requires a quantitative understanding of a variety of microphysical processes. We propose here to focus our studies on the most abundant of molecules, H2. To derive significant scientific return from current and future Spitzer observations, we will compute dissociation rate coefficients of H2 due to collisions of H, He, para-H2, and ortho-H2, a process which is competitive with other H2 destruction mechanisms. The rate coefficients will be computed for temperatures between 1 and 50,000 K and from ALL initial bound rotational-vibrational levels of H2 in the ground electronic state, information which is unavailable today. The computations will be performed using established quantum mechanical close-coupling and coupled-states methods on accurate, and well tested, potential energy surfaces. The results will be benchmarked against experiment, where available, and fit to analytic forms with physical low- and high-temperature limits for easy modeling use. The results of this proposal will then enable models, such as those from the widely used and tested spectral synthesis code Cloudy, to reliably simulate H2 in molecular environments, leading to deeper examination and understanding of their physical properties through Spitzer observations.

Spitzer Space Telescope - General Observer Proposal #30673

SN 1006: The Millennium Supernova Remnant

Principal Investigator: P. Frank Winkler
Institution: Middlebury College

Technical Contact: P. Frank Winkler, Middlebury College

Co-Investigators:
Stephen P. Reynolds, N. Carolina State Univ.
Kazimierz Borkowski, N. Carolina State Univ.
Knox S. Long, STScI
John C. Raymond, CFA
Parviz Ghavamian, Johns Hopkins Univ.
William P. Blair, Johns Hopkins Univ.

Science Category: ISM
Observing Modes: IrsMap MipsScan
Hours Approved: 18.0

Abstract:
We propose MIPS 24 and 70 micron imaging of the young Type Ia supernova remnant SN 1006. At a distance of only 2.2 Kpc and well off the Galactic plane, SN 1006 provides an exceptional opportunity for detailed studies of phenomena we have characterised at low spatial resolution by looking at similar objects in the LMC (Borkowski et al. 2006). We will study the dust processing (sputtering) and destruction of ISM dust by the fast (~2900 km/s) non-radiative shock wave, spatially resolving the destruction of the smallest grains as a function of distance behing the shock using the 70/24 micron ratio. Corrolating MIPS intensities against exquisite data available at other wavelengths, we will determine shock conditions (post-shock pressures, densities and temperatures) for both the synchrotron-dominated NE and SW limbs and for the thermally-dominated NW limb. Also, because SN 1006 contains well-documented regions of both shocked and unshocked ejecta, we will perform a careful search for ejecta dust, either detecting or placing very significant limits on its presence. We also request IRS low resolution 14-38 micron spectra of two contrasting limb positions (synchrotran and thermally-dominated) to validate assumptions needed to interpret the MIPS imagery, obtain detailed spectral shapes of the dust emission from these regions, and search for potential line emission from the fast shock.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #124

IRAC and MIPS Imaging and IRS Spectroscopy of Pre and Post Main Sequence Stellar Systems

Principal Investigator: Robert Gehrz
Institution: University of Minnesota

Technical Contact: Elisha Polomski, University of Minnesota

Science Category: ISM
Observing Modes: IracMap IrsMap IrsStare MipsPhot
Hours Approved: 29.6

Abstract:
We will obtain images of these systems to search for extended, faith ejecta and fossil remnants ejected in previous evilutionary phases. IRS follow-up will be used to determine the chemical composition and dynamics of the ejecta.

Spitzer Space Telescope - General Observer Proposal #30922

Cold Diffuse Clouds: The Missing Link in Molecular Cloud Formation

Principal Investigator: Steven Gibson
Institution: NAIC/Arecibo Observatory

Technical Contact: Steven Gibson, NAIC/Arecibo Observatory

Co-Investigators:
Marc-Antoine Marc-Antoine, IAS
Francois Francois, IAS
Christopher Brunt, U. Exeter
Russ Taylor, U. Calgary
William Reach, SSA
Alberto Noriega-Crespo, IPAC
Sean Carey, IPAC
Peter Martin, CITA

Science Category: ISM
Observing Modes: IracMap MipsScan
Hours Approved: 13.2

Abstract:
Recent results from the Canadian Galactic Plane Survey show that cold diffuse clouds are an important component of the Galactic interstellar medium. These clouds, detected as self-absorption features at 21 cm, have temperatures and densities that bridge the gap between the ambient atomic ISM and the colder, denser molecular medium. Consequently, they may be the long-sought sites where atomic gas condenses into the molecular phase required for star formation. Although critical to the evolution of matter in the Galaxy, molecular condensation is poorly understood, in large part because its quiescent nature renders it less detectable than more energetic phase changes like dissociation, ionization, or recombination. CDCs offer a unique opportunity to study this evolutionary ‘‘missing link’’. The question of the origin and stability of these structures is raised. Without molecular gas, the low temperatures of these cold diffuse clouds are difficult to explain, unless the standard heating and cooling mechanisms are not in the expected balance. As dust grains are directly involved in the heating (photo-electric effect on grains) and cooling (via the formation of molecules), infrared dust emission is an ideal tracer of the physical conditions of these structures. Here we propose to use Spitzer observations to put some strong constraints on the origin of these cold diffuse clouds. We wish use IRAC and MIPS to map a Galactic region well known for its abundant cold diffuse cloud features. The Spitzer data will allow us to fully characterize the dust size distribution, and to estimate the thermal balance of these structures. With its high angular resolution, the Spitzer data will also give us the opportunity to study in detail the small-scale structure of objects undergoing of one of the key transitions of the interstellar medium.

Spitzer Space Telescope - General Observer Proposal #30326

H2 Rotational Transition Emission From Molecular Cloud Edges: Tracing the Energy Input Affecting Cloud Structure and Evolution

Principal Investigator: Paul Goldsmith
Institution: JPL

Technical Contact: Thangsamy Velusamy, JPL

Co-Investigators:
Thangasamy Velusamy, JPL
Di Li, JPL
William Langer, JPL

Science Category: ISM
Observing Modes: IrsStare
Hours Approved: 25.1

Abstract:
We propose a study of the boundaries of molecular clouds to investigate the role of turbulent energy dissipation in heating these regions. Energy dissipated in cloud boundary layers may be injected into the molecular cloud, helping to support the dense region against gravitational collapse and thus lengthening the time available for star formation. Standard models of cloud boundaries predict only a limited quantity of warm H2, insufficient for detection at the present time. The inclusion of turbulent dissipation, suggested theoretically and by observations of diffuse clouds, can radically change the situation, resulting in > 10^{20} /cm^2 of H2 at temperatures > 100 K., sufficient for detection with Spitzer IRS. The warm H2 is plausibly located outside the region traced by carbon monoxide, thus forming a layer between the atomic hydrogen halo and the cooler molecular gas. We propose to carry out observations of three areas in the Taurus molecular cloud complex, including several boundaries demarcated in a carbon monoxide study of this region. Both the morphology and the kinematics of the 12CO and 13CO data indicate that the cloud edges are highly structured. By observing strips containing 11 pointings spaced over ~ 30′ with the LL1, LL2, and SL1 configurations of the IRS, we can observe the 4 lowest rotational transitions of H2 from within the bulk of the cloud, through the boundary, and beyond the cloud limits. We anticipate likely detection of the lowest [S(0); 28 micron] transition of para-H2, plausibly the lowest [S(1); 17 micron] transition of ortho-H2, and possibly the next higher transitions of each species. The critical point is that the relative intensities of the higher-J transitions are very sensitive to temperature, and thus are superb probes of heating above that predicted by "quiescent cloud" models. We thus feel that these Spitzer observations will make a very significant contribution to our understanding of molecular cloud structure and evolution.

Spitzer Space Telescope - General Observer Proposal #20146

Probing the Diffuse Interstellar Extinction Curve in the Spitzer Infrared

Principal Investigator: Karl Gordon
Institution: The University of Arizona

Technical Contact: Karl Gordon, The University of Arizona

Co-Investigators:
Karl Misselt, Univ. of Arizona
JD Smith, Univ. of Arizona
George Rieke, Univ. of Arizona
Geoff Clayton, Louisiana State Univ.
Yvonne Pendleton, NASA/Ames
Doug Whittet, Rensselaer Polytechnic Inst.
Ted Snow, Univ. of Colorado

Science Category: ISM
Observing Modes: IracMap IrsPeakupImage IrsStare MipsPhot
Hours Approved: 28.0

Abstract:
We propose to observe a sample of hot, reddened stars and closely matched comparison stars in order to measure the wavelength dependence of the diffuse interstellar extinction curve from 3-38 micron as a function of environment. These observations will be used to directly probe the dust and extend the empirical relationship found by Cardelli, Clayton, & Mathis (1989, CCM) into the Spitzer infrared. We will use IRS spectra from 5-38 microns, IRAC 3-8 micron, IRS blue peakup, and MIPS 24 micron photometry to ensure accurate photometric calibration. The extinction curves created from these data will represent the first accurate measurement of the extinction between 5 and 38 microns for along lines of sight which probe dust in the diffuse interstellar medium. A unique and valuable aspect of the proposed research will be the direct measurement of extinction from the UV to the far-IR in the same lines of sight enabling the extension of the empirical CCM relationship into the Spitzer infrared. In addition, dust parameters derived from these extinction curves will be far better constrained than in previous studies where the ultraviolet through near-IR extinction and mid-IR extinction curves were taken from different sightlines with different environmental conditions. The accurate measurement of the infrared extinction will provide valuable constraints on dust grain materials, both from prominent feature (eg.,10 micron silicate feature) and continuum extinction measurements as a function of environment [eg. R(V)]. The extension of the CCM relationship into the mid-infrared will undoubtedly be of use in many other Spitzer programs.

Spitzer Space Telescope - General Observer Proposal #40154

Probing Dust Grains Emissions in High Latitude Molecular Clouds

Principal Investigator: Karl Gordon
Institution: University of Arizona

Technical Contact: Karl Gordon, University of Arizona

Co-Investigators:
Adolf Witt, University of Toledo
Uma Vijh, Space Telescope Science Institute
Karl Misselt, University of Arizona
Steve Mandel, Hidden Valley Obs.

Science Category: ISM
Observing Modes: IracMap MipsScan
Hours Approved: 19.7

Abstract:
We are proposing to image two high latitude molecular clouds (HLMCs) with IRAC and MIPS to probe the changes with environment in the size distributions of dust grains responsible for dust emissions in the optical, infrared, and radio. The IRAC and MIPS images will probe the thermal emission from small and large grains (MIPS 70 & 160 micron), non-equilibrium emission from very small grains (IRAC & MIPS 24 micron), and mid-infrared PAH emission (IRAC 3.6 & 8.0 micron). Existing and planned medium-band optical observations will probe optical luminescence emission (Blue Photoluminescence and Extended Red Emission). Planned radio observations at 30 GHz will probe emission from spinning very small grains and PAHs. The combination of these datasets will provide strong constraints on dust grain models, especially on the mechanisms and rates for the changes of the grain size distribution through coagulation and fragmentation that occur in regions of varying gas and radiation densities.

Spitzer Space Telescope - General Observer Proposal #3234

Initial conditions of star formation: the clouds created around the expanding W4 supernova remnant

Principal Investigator: Jane Greaves
Institution: University of St Andrews

Technical Contact: Jane Greaves, University of St Andrews

Co-Investigators:
Ian Bonnell, University of St Andrews

Science Category: ISM
Observing Modes: MipsScan
Hours Approved: 6.0

Abstract:
The initial conditions for star formation in our Galaxy are difficult to establish. We seek to address this problem by imaging an archetypal region where new clouds are forming, around the periphery of the expanding supernova remnant W4. A 2-by-2 degree map with MIPS at 24 microns will reveal the structure of these clouds and their cores at unprecedented detail, with uniform imaging of scales of 0.1 up to 10 pc. A clump mass function will be constructed using temperature constraints from longer-wavelength data. This information on mass distribution and structure will then be compared to the results of our simulations of supernova impacts on the interstellar medium. Hence, the dominant forces on pre-star-forming clouds can be deduced.

Spitzer Space Telescope - Theoretical Research Proposal #50565

Identification of PAHs in Spitzer/IRS Spectra of the Icy Environments of YSOs: A Laboratory Study of PAHs embedded in H2O and D2O Ices

Principal Investigator: Satyanarayana Gudipati
Institution: Jet Propulsion Laboratory

Technical Contact: Satyanarayana Gudipati, Jet Propulsion Laboratory

Co-Investigators:
Michael Werner, Jet Propulsion Laboratory
Louis Allamandola, NASA Ames Research Center
Karl Stapelfeldt, Jet Propulsion Laboratory
Adwin Boogert, California Institute of Technology/IPAC

Science Category: ISM
Dollars Approved: 125000.0

Abstract:
Ices are the main reservoir of volatiles in dense clouds and the envelopes and disks surrounding Young Stellar Objects (YSOs). It is expected that the universally observed Polycyclic Hydrocarbon molecules (PAHs) freeze out on these ice grains. Laboratory experiments have shown that processing of these ices forms species of astrobiological interest. Spitzer/IRS spectra of over 40 YSOs have been analyzed to find several unassigned spectral features that may be due to PAHs embedded in H2O ices [Boogert et al. 2007]. However, lack of quantitative spectral data such as line widths, band shapes and absolute band depths for neutral and ionized PAHs in H2O ices hindered further identification. Recently we have shown that ionized PAHs are stable in astrophysical ices [Gudipati and Allamandola, 2004]. Bernstein et al. [2007] have measured spectra of neutral and ionized PAHs in H2O ices, covering only a narrow spectral region (7-10 microns), omitting the strong 6.2 and 11.3 micron bands essential to analyze the Spitzer/IRS spectra and the 3.3 micron band in complementary ground-based spectra. In order to quantify the PAH content, absolute band depths are needed, which were missing in this publication. We propose to extend the measurements of Bernstein et al. to derive quantitative laboratory mid-infrared (2.5-50 microns, including the Spitzer/IRS spectral range of 5?38 microns) data such as absolute line strengths, positions and widths of neutral and ionized PAHs in H2O and D2O ices. PAH spectra will be deconvolved from the ice-host spectra in the low-extinction regions of the H2O and D2O hosts. A range of PAH sizes will be used, one PAH at a time, embedded in the ice. The influence of CO2 on the PAH bands will also be quantified. These laboratory data will then be used to fit the unidentified features of already processed Spitzer/IRS data of icy mantles of over 40 YSOs and of spectra of background stars tracing quiescent cloud material covered in numerous legacy, GTO, and GO programs.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #19

SIRTF Observations of the Mid IR Features in Reflection Nebulae

Principal Investigator: James R. Houck
Institution: Cornell University

Technical Contact: Michael Werner, JPL

Science Category: ISM
Observing Modes: IracMap IrsStare MipsScan MipsSed
Hours Approved: 21.5

Abstract:
Reflection nebulae (RN) are valuable tools for the study of the interstellar infrared emission features (IEFs) (at 3.3, 6.2, 7.7, 8.6, 11.3 and 12.7 microns). The localized heating of an interstellar cloud by a nearby, optically visible star allows us to study the IEFs over varying excitation conditions by observing reflection nebulae illuminated by stars of different effective temperature. We will use a combination of MIPS, IRAC and the IRS to observe the IEFs in seven reflection nebulae with two major scientific approaches: (1) use the unprecedented sensitivity of SIRTF to detect and characterize IEF emission toward RN (vdb 47, 101 and 135) with very low illuminating stellar temperatures (and thus low UV to total flux ratios), which tests the various carrier/excitation models of the IEFs, in particular the PAH models which require high energy UV photons for excitation; and (2) obtain both the highest quality images and most complete wavelength-coverage spectra of the IEFs to date, by observing a sample of relatively bright RN (vdb 17, 52, 133, and 139). For both approaches, MIPS (24, 70, 160 microns) will be used to map the mid-IR emission and characterize the far-IR color temperature around the nebulae. IRAC will be used to map the distribution of IEF emission in the nebulae and to pinpoint the brightest emission spots for observation by the IRS. The IRS will provide spectra spanning from 5 to 40 microns, with lower spectral resolution of 60 at lambda < 10 microns, and higher spectral resolution (600) at lambda > 10 microns.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30951

Attorocks illuminated by K Giants

Principal Investigator: James R. Houck
Institution: Cornell University

Technical Contact: Bill Forrest, University of Rochester

Co-Investigators:
William Forrest, University of Rochester
Aigen Li, University of Missouri-Columbia

Science Category: ISM
Observing Modes: IrsMap IrsStare
Hours Approved: 0.6

Abstract:
The IRS observations of ~ 100 'debris' disks (Chen et al.\\ 2006) showed that many of the objects further than 100 pc distant were extended in LL or LH. This is incompatible with a debris disk and, rather, indicates the IR excess comes from interstellar medium (ISM) dust illuminated by a star (the ''Pleiades effect''). This extended emission is interesting in its own right. The spectra often show clear evidence for the 20 microns silicate emission feature (Figure 1). The temperature indicated is quite high, typically 110 K. Equilibrium calculations indicate that classical silicate grains, of radius 0.1 microns, would not be nearly this hot. If the grains are ultra small (i.e. 0.01 microns radius, 10 attogram mass), the superheat would be enough to explain this phenomenon. At that size, one must also consider single-photon stochastic heating.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40342

IRS Mapping of Attorocks

Principal Investigator: James Houck
Institution: Cornell University

Technical Contact: James Houck, Cornell University

Co-Investigators:
William Forrest, University of Rochester
Dan Watson, University of Rochester
Aigen Li, University of Missouri
Greg Sloan, Cornell University
Nuria Calvet, University of Michigan
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Lee Hartmann, University of Michigan
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Elise Furlan, University of California at Los Angeles
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Ciska Markwick-Kemper, University of Manchester
Mike Jura, University of California at Los Angeles
Tom Megeath, University of Toledo
Lori Allen, CfA
Judy Pipher, University of Rochester
Kevin Luhman, Penn State U.
Giovanni Fazio, CfA
James Muzerolle, University of Arizona
Kevin Flaherty, University of Arizona
George Rieke, University of Arizona

Science Category: ISM
Observing Modes: IrsMap
Hours Approved: 1.5

Abstract:
IRS 14-38 um spectra have provided strong evidence for extremely small silicate dust grains in the vicinity of B-type field stars. The signature of these very small (less than 1 attogram) rocks is an unusually high temperature, given their projected distance from the exciting star. We presently have 1-dimensional images (i.e. along the LL slit) of these attorock clouds. This data indicates a temperature which is independent of projected distance from the exciting star. This is one of the key signatures of stochastic heating by single photons. If stochastic heating, rather than equilibrium heating, is at play, then the precise size of the dust grains can be deduced from detailed modeling. We propose to make a 50x200 arcsecond map of the attorock clouds around the three most prominent attorock sources. We will convert this, via our modeling, to a map of silicate dust temperature, which will definitively confirm (or deny) stochastic heating. In addition, we propose to get SL data at the position 20" W of HR 1415, where we have the strongest evidence for attorocks, to look carefully for any PAH emission, which is surprisingly absent in the SL data we do have, i.e. along the SL slit perpendicular to the LL slit.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #4

Shedding light on Unusual Sources near the Galactic Center

Principal Investigator: James R. Houck
Institution: Cornell University

Technical Contact: Keven Uchida, Cornell University

Science Category: ISM
Observing Modes: IrsStare MipsScan
Hours Approved: 3.3

Abstract:
The Galactic center contains a number of unusual structures that manifest the physical extremes of the interstellar medium there. We use SIRTF to elucidate the physical conditions in several of these structures. The first is AFGL 5376, a remarkably bright and extended 25-micron source which appears to be a well-defined, large-scale, vertical shock associated with a radio continuum structure, the Galactic Center Lobe. We will detail the MIR structure and the spatial variation of the mid-infrared dust and ionized gas features across this object. The observations are intended to provide insights into both the shock kinematics as well as the nature of the dust in the ISM near the Galactic center. We also use the IRS to observe high excitation mid-IR atomic lines toward two other high energy features that are also likely to have resulted from activity unique to the Galactic center: Sgr AE and the radio "Streamers". Finally, high resolution spectral line observations of the putative sites of origin of the nonthermal radio filaments will provide constraints on the illuminating mechanism of these spectacular linear magnetic field lines.

Spitzer Space Telescope - General Observer Proposal #40928

The Silicate-Extinction Relationship as a Tracer of Evolution of Dust in Dense Cores

Principal Investigator: Tracy Huard
Institution: Smithsonian Astrophysical Observatory

Technical Contact: Tracy Huard, Smithsonian Astrophysical Observatory

Co-Investigators:
Klaus Pontoppidan, Caltech
Jeff Bary, University of Virginia
Jarron Leisenring, University of Virginia
Adwin Boogert, NOAO Gemini Science Center
Claudia Knez, University of Maryland
Jes Jorgensen, Smithsonian Astrophysical Observatory
Phil Myers, Smithsonian Astrophysical Observatory
Neal Evans, University of Texas at Austin

Science Category: ISM
Observing Modes: IrsStare
Hours Approved: 22.0

Abstract:
Spitzer IRS spectra of stars background to the dense regions of cores have been used to determine the relationship between the silicate optical depth and extinction. We have found that the dust within these cores is best characterized by Av/tau(silicate) ~ 50 +/- 10, significantly different from previous studies of dust in the diffuse ISM, which yield Av/tau(silicate) ~ 18.5 +/- 2. This result suggests that significant grain growth has occurred in these cores and the dust composition is different than that in the diffuse ISM. One starless core has been well probed with IRS spectra of background stars, yielding Av/tau(silicate) ~ 30 +/- 5. Our findings suggest that real core-to-core variations may exist. In most cases, with only a couple lines of sight probed in each core, the data are not sufficient to characterize these variations. We propose to obtain IRS spectra of a carefully selected sample of bright background stars probing a wide range of extinction in each core, for a set of cores, in order to better characterize this silicate-extinction relation and any core-to-core variations. This relationship appears to be one of the most sensitive tracers of grain properties, and with additional constraints from supplementary 1-1000 micron observations, we investigate implications for grain growth and evolution in these dense environments.

Spitzer Space Telescope - General Observer Proposal #20093

Heating and Cooling in the Translucent Interstellar Medium: Polycyclic Aromatic Hydrocarbons in High Galactic Latitude Clouds

Principal Investigator: James Ingalls
Institution: California Institute of Technology

Technical Contact: James Ingalls, California Institute of Technology

Co-Investigators:
Thomas Bania, Boston University

Science Category: ISM
Observing Modes: IrsStare
Hours Approved: 15.8

Abstract:
We propose to use Spitzer to make the first systematic study of the emission from unidentified infrared bands (UIBs) and [C II] in translucent clouds to provide the missing key empirical information needed to understand the energetics of translucent gas in the Milky Way. Current consensus ascribes the UIB emission features at 3.3, 6.2, 7.7, 8.6, 11.3, and 12.7 microns to result from fluorescent emission by PAH molecules excited by local FUV photons. If the UIBs are indeed caused by PAHs, then their observation in high--latitude clouds, coupled with existing measurements of [C II] and FIR emission will allow us to make the first direct assessment of the relative importance of heating by both large and small (PAH) grains. The sensitivity required to detect the UIBs in translucent HLCs cannot be achieved with ground based assets on a reasonable timescale, thus we wish to exploit the unprecedented sensitivity offered by the InfraRed Spectrograph (IRS) to measure the 5--15 micron UIB features in translucent clouds. To study the heating of HLCs systematically over a wide range of translucent cloud conditions, we are proposing to observe 11 positions out of 101 detected [C II] lines of sight in 4 HLCs. Our survey can be accomplished using 11 unconstrained (i.e., independently scheduled) AORs, each taking less than 1.5 hr.

Spitzer Space Telescope - General Observer Proposal #40207

Heating and Cooling in the Translucent ISM: PAHs and [C II] in High Galactic Latitude Clouds

Principal Investigator: James Ingalls
Institution: Spitzer Science Center

Technical Contact: James Ingalls, Spitzer Science Center

Co-Investigators:
Thomas Bania, Institute for Astrophysical Research, Boston Unive

Science Category: ISM
Observing Modes: IrsStare
Hours Approved: 22.7

Abstract:
The systematic study of the emission from unidentified infrared bands (UIBs) and [C II] in translucent clouds can provide the missing key empirical information needed to understand the energetics of translucent gas in the Milky Way. Current consensus ascribes the UIB emission features at 3.3, 6.2, 7.7, 8.6, 11.3, and 12.7 microns to fluorescent emission from PAH molecules excited by local FUV photons. Thus observation of the UIBs in high Galactic latitude molecular clouds (HLCs) coupled with existing measurements of [C II] and FIR emission, allow us to make a direct assessment of the relative importance of heating by both large and small (PAH) grains. In our GO-2 Spitzer program 20093, we detected the faintest PAH emission spectra in Galactic clouds to date, demonstrating the unique capabilities of the Spitzer IRS to spectrally image low-extinction regions. The derived PAH band strength in our HLC sample is linearly correlated with [C II] integrated intensity. The 7.7/11.3 micron intensity ratio, which is related to the PAH ionization fraction, appears to be inversely proportional to [C II]. Unfortunately the large scatter and paucity of data points in key regions of [C II]-space makes this potentially groundbreaking result difficult to establish reliably. The proposed IRS Short-Low observations will triple the sample size of HLC positions with both UIB and [C II] measurements from 11 to 33 lines of sight, with only a 1.4-fold increase in observatory time over our GO-2 program. It will fill the gaps in [C II] coverage in our UIB sample and greatly enhance the statistical significance of our results. Our ultimate goal is to clarify the relationship between PAH ionization fraction, which crucially affects gas heating, and [C II] intensity, which measures gas cooling. This research can dramatically improve our understanding of the most important processes that govern the thermal properties of ISM gas in low-extinction environments.

Spitzer Space Telescope - Directors Discretionary Time Proposal #491

Molecular Hydrogen Emission from Galaxies: The Cirrus Connection

Principal Investigator: James Ingalls
Institution: Spitzer Science Center

Technical Contact: James Ingalls, Spitzer Science Center

Co-Investigators:
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Francois Boulanger, IAS, Universite Paris-Sud
Bruce Draine, DAS, Princeton University
Edith Falgarone, CNRS, Ecole Normale Superiure & L'Observatoire de Paris
Pierre Hily-Blant, Lab. d'Astrophysique, L'Observatoire de Grenoble

Science Category: ISM
Observing Modes: IrsStare
Hours Approved: 5.3

Abstract:
Are cirrus clouds a major source of molecular hydrogen emission in normal Galaxies? This question caused a considerable debate during the 2007 Spitzer Conference. After the end of the cryogenic Spitzer mission, no existing or planned observatory will be capable of answering it for the known future. To remedy this, we propose a set of Spitzer IRS (LL) pointings to observe the two lowest-lying S(0) (28.2 micron) and S(1) (17.0 micron) pure-rotational transitions of H2 towards 4 translucent 'cirrus' positions in DCld 300.2-16.9, a known source of excited H2. Two of us unexpectedly discovered H2 S(2) emission at 12.3 microns in this cloud as part of our Spitzer GO program to study the 5-15 micron PAH spectrum. Relative to the integrated PAH flux at 7.9 microns, the S(2) flux in our cloud is higher by a factor of about 6 than the S(2) flux in non-active SINGS galaxies. One hypothesis currently in favor argues that H2 emission from the disks of galaxies results from fluorescent excitation by UV photons in dense photodissociation regions with high radiation fluxes. Clearly this cannot be the case for DCld 300.2-16.9, since the UV flux incident on the cloud cannot be greater than the average interstellar value. Yet this cirrus cloud is more efficient at exciting the S(2) transition into emission than the central disks of entire galaxies! A competing scenario is that the H2 rotational lines are excited by collisions in warm pockets of gas where turbulence dissipates. A full understanding of the excitation mechanism responsible for our H2 lines is impossible without measuring the lowest transitions on the rotational ladder. Such observations would also allow us to tally the total energy expended via the rotational transitions, which we can compare with available CII and FIR measurements, both of which are the result of UV heating; as well as planned CO measurements, which trace the turbulent velocity field. We are requesting 5.3 hours to observe 4 positions using Long Low staring mode.

Spitzer Space Telescope - General Observer Proposal #30174

The Vela X-1 and alpha Cam Bow Shocks as Probes of the Interstellar Medium

Principal Investigator: Rosina Iping
Institution: the Catholic University of America

Technical Contact: Rosina Iping, the Catholic University of America

Co-Investigators:
Lex Kaper, University of Amsterdam
George Sonneborn, NASA's GSFC

Science Category: ISM
Observing Modes: IracMap IrsStare MipsPhot
Hours Approved: 4.2

Abstract:
Bow shocks provide a way to probe their energetic environments and reveal properties of both the stellar wind and the ambient interstellar medium. We propose Spitzer IRS spectroscopy and IRAC and MIPS imaging to determine the dust characteristics and spatial variations and resolve filaments within the bow shocks of Vela X-1and alpha Cam. The presence of a bow shock indicates that the system has a high (supersonic) velocity with respect to the interstellar medium, in the process of which dust and gas is accumulated. The strong UV and X-ray radiation fields from the OB stars heat the dust and emission features are expected. The proposed observations, combined with multiwavelength data will permit us to determine hot and cold dust components, their spatial variations, and constrain the physical conditions in the shock interaction regions. The IR forbidden emission lines will determine the ionization structure of the shocked regions.

Spitzer Space Telescope - General Observer Proposal #20276

Key Atomic Species in the Chemistry of Molecular Outflows

Principal Investigator: Izaskun Jimenez-Serra
Institution: Instituto de Estructura de la Materia, CSIC

Technical Contact: Izaskun Jimenez-Serra, CSIC

Co-Investigators:
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Arturo Rodriguez-Franco, IEM-CSIC
Jose Cernicharo, IEM-CSIC

Science Category: ISM
Observing Modes: IrsStare
Hours Approved: 1.3

Abstract:
We propose to use the unmatched sensitivity of the IRS spectrograph of Spitzer to measure the abundances of key atoms found in young molecular outflows. The Mid-IR window contains the fine structure lines of SI, SiII, NeII and FeI which are fundamental to understand the Sulphur and the Silicon chemistry in shocks and to establish the presence of J-type shocks and their radiative precursors. The detection of large abundance of Sulphur in the very young molecular outflows where the shock precursors have been recently detected will clearly show that atomic Sulphur is ejected from the grains and drives the very rich sulphur chemistry observed in outflows. We stress that IRS onboard of Spitzer is the only instrument capable of detecting the key atoms to understand the nature of the shocks (C- and J-types) and the shock chemistry in molecular outflows.

Spitzer Space Telescope - General Observer Proposal #40898

Physical evolution of Very Small Grains: excitation and processing in extreme environments

Principal Investigator: Christine Joblin
Institution: Centre d'Etudes Spatiale des Rayonnements

Technical Contact: Alain Abergel, Institut d'Astrophysique Spatiale

Co-Investigators:
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Jean Phillipe Bernard, CESR
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Francois Boulanger, IAS
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William Reach, SSC
Mathias Rapacioli, Dresden Technishe Universitat
Markus Roellig, Cologne University
Robert Simon, Cologne University
Aude Simon, CESR

Science Category: ISM
Observing Modes: IrsMap IrsStare MipsSed
Hours Approved: 16.3

Abstract:
The nature of the dust population called the Very Small Grains (VSGs) is still poorly known. Recent studies show that they contain aromatic nanograins which could be PAH clusters, In this program, we aim at constraining the nature and size distribution of VSGs by studying their physical and chemical evolution from their initial exposure to UV radiation to their destruction in harsh UV irradiation conditions. We will use IRS in spectral mapping mode and MIPS in SED mode to study the shock-induced PDR in HH2, four extended HII regions and their interface to the Molecular cloud (Horsehead, Rosette, Carina-S, CepB-N) sampling different excitation conditions in terms of UV photon intensity and hardness. Finally we will observe the UC HII region MonR2 where extreme irradiation is prevailing. The analysis of the data will be performed by a very interdisciplinary team gathering observational, signal processing, theoretical, experimental and modelling skills to study the photophysics and chemistry of carbonaceous macromolecules and nanograins in interstellar space.

Spitzer Space Telescope - General Observer Proposal #50146

UV processing of ices across the Rosette molecular cloud

Principal Investigator: Jacqueline Keane
Institution: Institute for Astronomy, University of Hawaii

Technical Contact: Jacqueline Keane, IfA, University of Hawaii

Co-Investigators:
Jonathan Williams, Insititute for Astronomy, Hawaii
Edwin Bergin, University of Michigan
Elizabeth Lada, University of Florida
Ian Bonnell, University of St. Andrews

Science Category: ISM
Observing Modes: IrsStare
Hours Approved: 9.6

Abstract:
During star-formation, materials in the general cloud medium are subjected to numerous chemical and physical processes that are driven mostly by thermal and energetic radiation. In part because of Spitzer, significant progress has been made towards understanding the various effects of these radiation processes on the ices and organics as they form and cycle through the dense and diffuse regions of molecular clouds and subsequently become incorporated into (proto)stellar environments (i.e planets, comets, etc.). However, to date the majority of the focus has been directed at clouds (such as Taurus-Auriga) that are NOT analogous to the molecular cloud from which the solar nebula originated. Rather, the Sun formed in a high mass star-forming cloud where a number of supernova events occurred, resulting in intense UV radiation throughout the cloud complex, such as the Rosette Nebula. We propose to take low resolution spectra from 5 to 22 microns along the line of sight toward 13 sources in 8 embedded clusters in the Rosette molecular cloud. The clusters are all deeply embedded, indicative of a similar formation time but have a range of luminosities and are spread out across the cloud at different distances from the neighboring HII region, NGC 2244. We will also take high resolution spectra from 10 to 20 microns toward the 5 brightest and most embedded sources to examine the CO_2 line profile in detail. This will allow us to determine the mixture of different ices and thereby the temperature and radiation processing history in each region. These observations will reveal how the ice composition in each cluster envelope varies with environment, both locally from the embedded sources and globally due to the heating and UV radiation from NGC 2244. Differences in gas phase chemistry have already been observed at millimeter wavelengths and we will use these mid-infrared data to obtain a more complete picture of the chemistry.

Spitzer Space Telescope - Directors Discretionary Time Proposal #1094

The composition and evolution of dust in astrophysical environments

Principal Investigator: Francisca Kemper
Institution: University of California, Los Angeles

Technical Contact: Francisca Markwick-Kemper, UCLA

Science Category: ISM
Observing Modes: IracMap IrsMap IrsStare MipsPhot
Hours Approved: 16.0

Abstract:
Dust is produced in the circumstellar environments of evolved stars and then ejected by a stellar wind into the surrounding interstellar medium (ISM). Here, it may reside for a long time (> 10^9 years) before it ends up in a molecular cloud where star formation takes place. When a star is formed, in many cases a dusty disk remains from which a planetary system may form as well. Both within the ISM and in the winds from cool stars, about half of the matter heavier than helium is contained within solid particles. Therefore, dust is an important tracer of the physical conditions in astrophysical environments. By measuring the composition of the dust grains we can study the formation and processing of the material, and thus derive a record of the physical circumstances. As we understand better the physics of dust in our own Galaxy, we will be better able to use infrared studies of other galaxies to learn about their history and use this knowledge to interpret dusty systems at high redshift. I will work on the formation and evolution of dust in the Galaxy and the Magellanic Clouds. From previous studies performed with IRAS, the Kuiper Airborne Observatory (KAO), and the Infrared Space Observatory (ISO), we have learned that the composition of interstellar dust is very different from that of circumstellar dust. I plan to pursue a vigorous observational program which uses the unique capabilities of SIRTF to quantitatively investigate the life cycle of dust in the Milky Way and the Magellanic Clouds. I propose to determine the composition of the dust in various astrophysical environments using the spectroscopy modes offered on SIRTF, in order to study the formation and processing of the identified dust species. For this purpose the spectrographic data will be compared to optical constants of astrophysically relevant minerals, derived from laboratory measurements.

Spitzer Space Telescope - General Observer Proposal #3490

Investigation of Red Emission from Interstellar Dust Clouds

Principal Investigator: Gillian Knapp
Institution: Princeton University

Technical Contact: Gillian Knapp, Princeton University

Co-Investigators:
Douglas Finkbeiner, Princeton University
David Schlegel, Princeton University
Peregrine McGehee, New Mexico State University

Science Category: ISM
Observing Modes: IracMap
Hours Approved: 3.1

Abstract:
SDSS r, i and z maps of the Taurus dust clouds show that, unlike dust clouds seen in several other regions of sky, these clouds glow in the z band. We propose to make maps at all four IRAC bands of an approximately 1degreex1degree region of the Taurus clouds chosen to show a lot of structure in the red emission and a similar map of a region in the Orion dust clouds which does not show this emission. We hope, by combining and modeling these maps, to investigate the mechanism which produces the red glow and whether it is due to solid-state emission features from small grains.

Spitzer Space Telescope - General Observer Proposal #40580

A systematic study of ice and dust properties in large clouds and their relation to star formation activity

Principal Investigator: Claudia Knez
Institution: University of Maryland, College Park

Technical Contact: Claudia Knez, University of Maryland, College Park

Co-Investigators:
Jean Chiar, SETI Institute
Lee Mundy, University of Maryland
Adwin Boogert, AURA/NOAO-South
Yvonne Pendleton, NASA Ames
Alexander Tielens, NASA Ames
Ewine van Dishoeck, Leiden University

Science Category: ISM
Observing Modes: IrsStare
Hours Approved: 40.1

Abstract:
We propose to obtain 5-38 micron IRS spectra toward 88 background stars toward three molecular clouds to trace the evolution of ice and dust properties from edges of the clouds to the dense cores. Previous studies have shown there are differences in ice and dust content between clouds and within the same cloud. To determine how star formation activity affects these variations, we plan to study systematically three clouds with differing level of star formation activity: Serpens Cloud Core (high activity), Perseus Cloud (intermediate activity) and Lupus (low activity). The sources were selected to probe different ranges of visual extinction as well as different locations within the clouds.

Spitzer Space Telescope - General Observer Proposal #50495

Spitzer Spectroscopy of the Mysterious Infrared Source IRAS 15099-5856

Principal Investigator: Bon-Chul Koo
Institution: Seoul National University

Technical Contact: Bon-Chul Koo, Seoul National University

Co-Investigators:
Dae-Sik Moon, University of Toronto
Myungshin Im, Seoul National University
Jae-Joon Lee, Penn State University
Woong-Seob Jeong, ISAS/JAXA

Science Category: ISM
Observing Modes: IrsStare
Hours Approved: 0.6

Abstract:
We have recently discovered a mysterious, bright mid-infrared object in the Galactic plane using the Infrared Camera aborad AKARI satellite. This object, IRAS 15099-5856, is composed of a bright central compact source, knots and spurs surrounding it, and several extended arc-like filaments. The SED of the central compact source increases steeply from 10 to 25 um with a spectral index of -6.5, and remains flat at 30 Jy to 90 um. The source does not have a counterpart in other wave bands except two possible candidates of 19th Ks-mag point sources. We can think of post-AGB stars with thick envelope, highly-embedded class 0 protostars, or infrared-luminous galaxies, but none of them seems to explain the observed mid-infrared properties. IRAS 15099-5856 can potentially be a unique source of a new class. In order to unveil the hidden mysterious nature of the object, we propose to carry out Spitzer IRS observations. We ask 0.55 hrs of total observing time.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #94

Search for Low-Luminosity YSOs and Measurement of Infrared Extinction in Dark Clouds and Bok Globules

Principal Investigator: Charles Lawrence
Institution: JPL

Technical Contact: Jocelyn Keene, JPL

Science Category: ISM
Observing Modes: IracMap
Hours Approved: 23.4

Abstract:
This project is a survey of 50 Bok Globules and 2 dark clouds at IRAC wavelengths searching for embedded very low luminosity YSOs. With these data we will also derive extinction profiles of the globules. Comparisons to 2MASS observations will enable extension of the near-infrared extinction curve to 8 microns under a varity of density conditions. Comparisons with MIPS maps of the same sources, from a separate projects, will allow a derivation of the far-infrared dust emissivity.

Spitzer Space Telescope - General Observer Proposal #20420

Spitzer Observations of the Molecular Cloud toward HD 62542: A Sightline with Exceedingly Anomalous 2175 Angstrom Extinction Bump

Principal Investigator: Aigen Li
Institution: University of Missouri-Columbia

Technical Contact: Aigen Li, University of Missouri-Columbia

Co-Investigators:
Karl Misselt, Steward Observatory, University of Arizona
J.D. Smith, Steward Observatory, University of Arizona
Bruce Draine, Princeton University
Zhong Wang, CfA-Harvard

Science Category: ISM
Observing Modes: IracMap IrsStare MipsPhot
Hours Approved: 6.8

Abstract:
The 2175 Angstrom bump is the strongest spectroscopic interstellar extinction feature. Its carrier remains unidentified 40 years after its first detection. The molecular cloud toward HD 62542 is of special interest, because the extinction toward HD 62542 exhibits an exceedingly anomalous 2175 Angstrom bump -- extremely broad and weak and peaking at 2110 Angstrom, in marked contrast to the near-invariant peak wavelength of 2175 Angstrom for most sightlines. We propose to perform low-resolution IRS spectroscopic observations (from 5--40 micron in both SL and LL modes), IRAC 3.5, 4.5, 5.8, 8 micron and MIPS 24, 70 micron imaging observations of the HD 62542 cloud. These data, when combined with existing extinction, polarization, and the 12, 25, 60, and 100 micron IRAS broadband photometry data, will allow us (1) to quantitatively constrain the properties of the dust in this cloud and in particular, those of the ultrasmall grains (e.g. PAHs); (2) to test the silicate/graphite-PAH model developed for the Milky Way diffuse interstellar medium and shown successful when applied to reflection nebulae and other galaxies; (3) to test the PAH model as the carrier of the 2175 Angstrom interstellar extinction hump; (4) to study the dust properties in relation to the interstellar environment.

Spitzer Space Telescope - Theoretical Research Proposal #30199

Modeling the Destruction and Survival of PAHs in Astrophysical Regions: from Low-metallicity Galaxies to Elliptical Galaxies and Galactic Halos

Principal Investigator: Aigen Li
Institution: University of Missouri-Columbia

Technical Contact: Aigen Li, University of Missouri-Columbia

Science Category: ISM
Dollars Approved: 82798.0

Abstract:
The 3.3, 6.2, 7.7, 8.6 and 11.3 micron emission features of polycyclic aromatic hydrocarbon (PAH) molecules have been seen in a wide variety of Galactic and extragalactic objects. However, the PAH features are weak or absent in low-metallicity galaxies and AGN, as generally interpreted as the destruction of PAHs by hard UV photons in metal-poor galaxies or by extreme UV and soft X-ray photons in AGN. On the other hand, the PAH emission features have recently been detected in elliptical galaxies, tidal dwarf galaxies, galaxy halos, and distant galaxies at redshift >=2. However, it is not clear how PAHs can survive in elliptical galaxies containing X-ray emitting hot gas where PAHs are expected to be easily destroyed through sputtering by hot plasma ions. It is also not clear how PAHs get ‘‘levitated’’ and survive from galactic plane to galaxy halo where the physical conditions are similar to those of elliptical galaxies. We propose to study the destruction of PAHs (1) by UV photons in low-metallicity galaxies, (2) by extreme UV and X-ray photons in AGN, (3) by intense UV radiation in regions with strong star-forming activities, and (4) through sputtering by plasma ions in hot gas. This will allow us, by the first time, to quantitatively investigate the deficiency or lack of PAHs in AGN and low-metallicity galaxies, as well as the survivability of PAHs in elliptical galaxies, galaxy halo, and superwind, and the method of using the IRAC 8 micron photometry as a tracer of star formation rates. This program will create a web-based ‘‘library’’ of the destruction rates of PAHs by UV and X-ray photons as a function of size, intensity and hardness of the radiation field, and the sputtering rates of PAHs by plasma ions as a function of size, gas density and temperature. This library will be made publicly available to the astronomical community by May 2007 on the internet at http://www.missouri.edu/~lia/.

Spitzer Space Telescope - General Observer Proposal #3669

Spitzer Observations of the High-Latitude Translucent Cloud toward HD 210121: A Sightline with Exceedingly Anomalous Ultraviolet Interstellar Extinction

Principal Investigator: Aigen Li
Institution: University of Missouri-Columbia

Technical Contact: JD Smith, University of Arizona

Co-Investigators:
JD Smith, Steward Observatory, University of Arizona
Bruce Draine, Princeton University
Karl Misselt, Steward Observatory, University of Arizona

Science Category: ISM
Observing Modes: IrsMap MipsPhot
Hours Approved: 6.2

Abstract:
The dust content in the high-galactic latitude translucent molecular cloud toward HD 210121 is of special interest. This is because the extinction curve of this sightline exhibits a far-ultraviolet rise that is among the steepest ever observed and has an exceptionally small total-to-selective extinction ratio (R_V = 2.1). We propose to perform low-resolution IRS spectroscopic observations (from 5--40 micron in both SL and LL modes) and MIPS 24, 70 and 160 micron imaging observations of the HD 210121 cloud. These data, when combined with existing extinction, polarization, and the 12, 25, 60, and 100 micron IRAS broadband photometry data, will allow us (1) to quantitatively constrain the properties of the dust in this cloud and in particular, those of the ultrasmall grains (e.g. PAHs); (2) to test the silicate/graphite-PAH model developed for the Milky Way diffuse interstellar medium and shown successful when applied to reflection nebulae and other galaxies; (3) to test the PAH model as the carrier of the 2175 Angstrom interstellar extinction hump which remains unidentified for 39 years since its first discovery; (4) to study the dust properties in relation to the interstellar environment.

Spitzer Space Telescope - Theoretical Research Proposal #40674

Modeling the Infrared Emission Spectra of Specific PAH Molecules in Interstellar Space

Principal Investigator: Aigen Li
Institution: University of Missouri, Columbia

Technical Contact: Aigen Li, University of Missouri, Columbia

Science Category: ISM
Dollars Approved: 87146.0

Abstract:
The 3.3, 6.2, 7.7, 8.6 and 11.3 micron emission features ubiquitously seen in a wide variety of Galactic and extragalactic objects, are generally attributed to polycyclic aromatic hydrocarbon (PAH) molecules. Although the PAH hypothesis is quite successful in explaining the general pattern of the observed emission spectra, so far there is no actual precise identification of a single specific PAH molecule in interstellar space. Therefore, when modeling the observed PAH emission spectra, astronomers usually take an empirical approach by constructing "astro-PAHs" which do not represent any specific material, but approximate the actual absorption properties of the PAH mixture in astrophysical regions. We propose a Spitzer Theory Program to study the photoexcitation of specific PAH molecules and their ions in interstellar space, taking a statistical-mechanical (instead of thermal) approach. For most of the specific PAH molecules selected for this research (with a small number of vibrational degrees of freedom), thermal approximation is not valid. Using available laboratory and quantum-chemical data (e.g. vibrational frequencies, UV/visible/IR absorption cross sections), we will calculate the emission spectra of 21 representative specific PAH molecules and their ions, ranging from naphthalene to circumcoronene, illuminated by interstellar radiation fields of a wide range of intensities. This program will create a web-based "library" of the emission spectra of 21 specific PAH molecules and their ions as a function of starlight intensities. This "library" will be made publicly available by October 2008 on the internet at http://www.missouri.edu/~lia/. By comparing observed PAH spectra with model spectra produced by co-adding the emission spectra of different PAH molecules available in this "library" (with different weights for different species), one will be able to estimate the total PAH mass and relative abundances of each PAH species, using real PAH properties.

Spitzer Space Telescope - General Observer Proposal #30382

Star Formation and Structure in two High-Latitude Molecular Clouds

Principal Investigator: Loris Magnani
Institution: University of Georgia

Technical Contact: William Reach, Caltech

Co-Investigators:
William Reach, SSC/Caltech
James Ingalls, SSC/Caltech
Thomas Hearty, JPL/Caltech
Doug Finkbeiner, Princeton University

Science Category: ISM
Observing Modes: IracMap MipsScan
Hours Approved: 20.4

Abstract:
We propose to use the Spitzer telescope to study the star formation history and the turbulence characteristics of two high-latitude molecular clouds, MBM 12, and G236+39. MBM 12 is a high-latitude molecular cloud at the translucent/dark cloud boundary that is forming low-mass stars. The cloud G236+39 appears very similar to MBM 12 on the IRAS 100 micron images, but is somewhat fainter, has lower average gas column density and a lower visual extinction than MBM 12. G236+39 is more typical of high-latitude clouds in that it is translucent and is not known to be forming stars. By using MIPS and IRAC images, we propose to identify all newly-formed stars in the molecular portions of the clouds, determine the star formation efficiency of both clouds, and better constrain the parameters of what types of translucent clouds can form stars and what types will simply dissipate. In addition to determining the star-forming capabilities of both clouds, we will construct spatial power law spectra of surface brightness to study the turbulence characteristics of the clouds.

Spitzer Space Telescope - General Observer Proposal #30459

Extinction and Emission by Grains in the Diffuse ISM

Principal Investigator: Derck Massa
Institution: SGT, Inc.

Technical Contact: Derck Massa, SGT, Inc.

Co-Investigators:
Edward Fitzpatrick, Villanova

Science Category: ISM
Observing Modes: IrsMap
Hours Approved: 6.1

Abstract:
We propose to obtain low resolution IRS short and long wavelength spectra of both stars and diffuse PAH emission in a carefully selected sample of stars. This sample is composed of stars with well determined UV extinction curves and which are shown to lie beyond all of the extincting and emitting dust along their lines of sight. The new observations are designed to provide IR extinction curves and high quality PAH emission spectra for the program sight lines. Our sample includes sight lines whose UV curve extinction curves exhibit a wide range of curve morphology and which sample a variety of interstellar environments. As a result, this unique sample will enable us to study the connection between the extinction and emission properties of the grains and to examine their response to different physical environments. We discuss how these results will provide clues to the composition of interstellar grains and facilitate the modeling of the grain populations along selected lines of sight.

Spitzer Space Telescope - General Observer Proposal #20434

A Mid and Far-Infrared Study of IC 405: PAH and Dust Emission in a Diverse Enviroment

Principal Investigator: Stephan McCandliss
Institution: Johns Hopkins University

Technical Contact: Stephan McCandliss, Johns Hopkins University

Co-Investigators:
Kevin France, Johns Hopkins University

Science Category: ISM
Observing Modes: IracMap IrsMap MipsScan
Hours Approved: 3.3

Abstract:
IC 405 is a reflection/emission nebula recently ''switched on'' by the transit of the runaway 09V star HD 34078. IC 405 has been shown to have a clumpy dust distribution and a highly excited population of H_2. The clumpy dust distribution is expected to produce highly anisotropic scattering of the stellar far ultraviolet radiation field. We predict that variations in the intensity of the UV radiation field will tend to destroy small PAH particles and H_2 in isolated regions. This effect maybe manifest in the relative strength of the 8.6~$\\mu$m feature, presumably due to photodistruction or ionization of the carrier. The clumpy nature of the gas and dust in IC 405 produces a high degree of differential absorption of UV radiation within the nebula. Consequently, we also expect the reradiated thermal infrared to exhibit temperature gradients. We expect these gradients in PAH size distribution, H$_{2}$ column emission, and dust temperature to be higher in IC 405 than in the well studied reflection nebula NGC 7023 where the dust distributions and radiation field variations are less clumped. We propose $Spitzer$ IRAC, IRS, and MIPS observations of IC 405, to test the environmental dependence of PAH emission, look for correlation's between PAHs and fluorescent H$_{2}$, and create a detailed map of the dust temperature of these regions.

Spitzer Space Telescope - General Observer Proposal #20797

Mapping the Structure of Dark Filaments in OMC 3 with the IRS

Principal Investigator: Tom Megeath
Institution: Harvard Smithsonian Center for Astrophysics

Technical Contact: Tom Megeath, Harvard, CfA

Co-Investigators:
Judy Pipher, University of Rochester
Dawn Peterson, University of Viriginia
Phil Myers, Harvard Smithsonian Center for Astrophysics
Di Li, Harvard Smithsonian Center for Astrophysics
Lori Allen, Harvard Smithsonian Center for Astrophysics

Science Category: ISM
Observing Modes: IrsMap
Hours Approved: 11.8

Abstract:
We propose a novel method for molecular clouds by measuring the attenuation of an extended mid-IR nebula by a cold foreground cloud. Such nebula have a characteristic spectrum with bright spectral features thought to arise from polycyclic aromatic hydrocarbons. By measuring the variable attenuation of these features by the cold dust cloud, and particular, the silicate absorption feature, we can measure the column density through the filament. We will map dark filaments in the Orion Molecular Cloud 3 regions, and use these to understand the structure of the filaments and how they fragment into stars.

Spitzer Space Telescope - General Observer Proposal #3423

The Structure and Evolution of Proto-Stellar Outflow Shocks

Principal Investigator: Gary Melnick
Institution: Harvard-Smithsonian Center for Astrophysics

Technical Contact: Gary Melnick, Harvard-CfA

Co-Investigators:
Edwin Bergin, University of Michigan
William Forrest, University of Rochester
Michael Kaufman, San Jose State University
David Neufeld, Johns Hopkins University
Judith Pipher, University of Rochester
Dan Watson, University of Rochester

Science Category: ISM
Observing Modes: IrsMap
Hours Approved: 22.5

Abstract:
Outflows from young stellar objects are the most prominent signs of star formation. Unfortunately, the connection between the strength of the ouflow and the properties of the driving source is not fully understood, and remains an area of intense study. Outflows also drive shocks that can significantly alter the composition of the gas into which they propagate. However, the chemical changes they induce are a sensitive function of the shock velocity and pre-shock density. Because the IRS instrument provides access to a variety of low-lying rotational lines of H2, ground-state rotational transitions of H2O, and several atomic and ionic fine-structure lines, it is particularly well-suited to study these problems. Specifically, we propose to use the H2 S(0) through S(5) lines to obtain the shock luminosity to compare with the mechanical luminosity and the protostellar models of six well-studied outflow sources. Use of these mid-IR H2 lines greatly reduces the uncertainties in the derived luminosity resulting from poorly known extinction corrections. Simultaneously, we propose to use the H2, H2O, [FeI], [SI], [FeII], and [SiII] lines in the IRS band to study the spatial distribution of any fast dissociative and slower non-dissociative shocks that may be present. The high spatial resolution of the IRS will permit us to better determine the filling factor and abundance of hot water in these sources -- something that was not possible with the lower angular resolution of ISO and SWAS. For each of the observed sources we will carry out mapping observations in a ~1'x1' field centered on one lobe of each outflow. The observations will be performed using the IRS in spectral mapping mode. This includes use of the Short-Lo, Short-Hi, and Long-Hi modules to obtain complete coverage throughout the 5.3 - 37.0 micron spectral region. The sensitivity obtained will exceed that possible from an ambient temperature telescope by several orders of magnitude and will allow the detection of all of the key diagnostics.

Spitzer Space Telescope - General Observer Proposal #50043

Connecting the Extinction Curve from the UV to the Spitzer Infrared

Principal Investigator: Karl Misselt
Institution: University of Arizona

Technical Contact: Karl Misselt, University of Arizona

Co-Investigators:
Karl Gordon, STSci
Ted Snow, Univ. of Colorado
George Rieke, Steward Observatory, U of Arizona
Geoff Clayton, Louisiana State University
Yvonne Pendleton, NASA
Douglas Whittet, RPI
Dean Hines, Space Science Institute
Adam Jensen, Goddard Space Flight Center

Science Category: ISM
Observing Modes: IracMap IrsStare MipsPhot IrsPeakupImage
Hours Approved: 11.8

Abstract:
We propose to observe a sample of hot, reddened stars to measure the wavelength dependence of interstellar extinction from 3-24 um along lines of sight probing the dense, high optical depth environments of interstellar clouds. We will use IRAC (3-8 um), IRS (low resolution, 5-21 um), IRS-PUI (15 um), and MIPS (24 um) to measure the infrared extinction curve for a sample of stars with A(V) up to ~7.5. With the installation of the Cosmic Origins Spectrograph (COS) on HST, UV observations with high S/N towards high A(V) lines of sight will possible for the first time. Spitzer provides the first opportunity to observe silicate features in the infrared along sightlines with UV extinction curves. The complementarity of the two instruments represents an unprecedented opportunity to measure extinction curves from the UV through the IR along such high optical depth lines of sight. The availability of extinction curves covering the full wavelength range from the UV through IR supplied by this program will provide a unique probe the effects of environment on grain formation, growth, and destruction. Additionally, the accurate measurement of the IR extinction curve along dense sight lines will provide insight into the nature of interstellar dust as a function of environment, both from prominent solid state features (e.g. 10/18 um silicate) and the shape of the continuum extinction.

Spitzer Space Telescope - General Observer Proposal #50106

Dust formation in V838 Mon and V4332 Sgr

Principal Investigator: Karl Misselt
Institution: University of Arizona

Technical Contact: Karl Misselt, University of Arizona

Co-Investigators:
Kate Su, Steward Observatory
Dipankar Banerjee, Physical Research Laboratory
Nagarhalli Ashok, Physical Research Laboratory
Massimo Marengo, CfA

Science Category: ISM
Observing Modes: IracMap IrsStare MipsPhot
Hours Approved: 2.9

Abstract:
We propose follow-up observations of the unusual eruptive variables V838 Monocerotis (V838 Mon) and V4332 Sagitarrii (V4332 Sgr) to study the early formation and evolution of dust condensates in their ejecta. Both underwent powerful eruptions (2002 and 1994, respectively) characterized by multiple peaks and cool super-giant like spectra. Shortly after eruption, an optical light echo was discovered around V838 Mon. Spitzer observations carried out by us revealed the presence of an extremely rare infrared light echo and suggest an interstellar origin for the material. While no extended emission has been noted around V4332 Sgr, it spectrum (both in the optical and the Spitzer infrared) is characterized by the presence of rare AlO radicals. More recently, our Spitzer data have shown the presence of alumina and titanium oxides in the ejecta around V4332 Sgr, the older of the two eruptions. Spectra of V838 Mon have also shown strong evidence for the presence of the these early dust condensate species. In addition to their infrared evolution, both objects have been seen to undergo significant evolution in their optical spectra. The ongoing formation and evolution of dust condensates in the ejecta of both objects provides a unique opportunity to study and test theories of dust condensation in oxygen rich environments.

Spitzer Space Telescope - General Observer Proposal #30167

Spitzer observations of hydrogen deuteride (HD)

Principal Investigator: David Neufeld
Institution: The Johns Hopkins University

Technical Contact: David Neufeld, The Johns Hopkins University

Co-Investigators:
Paule Sonnentrucker, Johns Hopkins University
Dan Watson, University of Rochester
Bill Forrest, University of Rochester
Joel Green, University of Rochester
Edwin Bergin, University of Michigan
Gary Melnick, Harvard-Smithsonian CfA

Science Category: ISM
Observing Modes: IrsMap
Hours Approved: 44.9

Abstract:
We propose to carry out Spitzer/IRS observations of interstellar hydrogen deuteride (HD). The proposed program follows up our recent detection of the HD R(3) and R(4) transitions at 28.50 and 23.04 microns in Spitzer observations of shocked molecular gas in the supernova remnant IC443C; as well as tentative detections of warm HD in the Herbig-Haro objects HH54 and HH7, and in the star-forming region GGD37 (Cepheus A West). Using integration times a factor of 14 - 60 larger than the short integrations we have obtained to date, we expect to obtain signal-to-noise ratios sufficient to confirm and map the HD emission in HH54, HH7, and GGD37. These data will provide a more precise measurement of the HD R(4)/R(3) ratio in all four sources, allowing us to model the non-LTE excitation of HD reliably and determine the HD abundance and gas density. In addition to the Long-High observations needed to measure HD R(3) and R(4), we will carry out Short-Low observations of the H2 S(2) through S(7) lines in GGD37; these observations - which are already in hand for the other three sources - are essential to measure the column density of warm H2 in the source, without which the HD/H2 abundance ratio cannot be determined. The results of this investigation will greatly expand the sample of interstellar gas clouds in which the HD abundance has been measured, observations prior to Spitzer having only identified HD in a single source (the Orion Molecular Cloud). The results will have important implications for our understanding of the chemistry of deuterium-bearing molecules, and of the evolution of the elemental abundance of deuterium in our Galaxy.

Spitzer Space Telescope - General Observer Proposal #40121

Spitzer spectral line mapping of interstellar shock waves: probing the physics and chemistry of shocked molecular clouds

Principal Investigator: David Neufeld
Institution: Johns Hopkins University

Technical Contact: David Neufeld, Johns Hopkins University

Co-Investigators:
Zita Banhidi, Stockholm Observatory
Ted Bergin, University of Michigan
Teresa Giannini, Osservatorio Astronomico di Roma
Rolf Guesten, MPI fuer Radioastronomie
Michael Kaufman, San Jose State University
Rene Liseau, Stockholm Observatory
Gary Melnick, Harvard-Smithsonian CfA
Brunella Nisini, Osservatorio Astronomico di Roma
Sabine Philipp, MPI fuer Radioastronomie
Volker Tolls, Harvard-Smithsonian CfA

Science Category: ISM
Observing Modes: IrsMap
Hours Approved: 141.1

Abstract:
We propose to carry out a comprehensive, spectroscopic imaging study of interstellar shock waves in molecular clouds, in which the IRS instrument will be used to obtain spectral line maps with complete wavelength coverage over the 5.2 to 37 micron spectral region and at the highest spectral resolution achievable with IRS. By observing, in their entirety, five protostellar outflows with diverse properties, and two shocked molecular clumps within the supernova remnant IC433, we will probe the physics and chemistry of interstellar shock waves in a wide variety of environments. All the sources that we propose to observe are also be targeted for spectroscopic observations in Guaranteed Time Key Projects of the Herschel Space Observatory, providing an important synergy between the mid-IR spectroscopy that is possible with Spitzer and the far-IR and submillimeter spectroscopy to be carried out by Herschel. The wavelength range covered by Spitzer/IRS provides access to 15 fine structure transitions of NeII, NeIII, SiII, PII, SI, SII, ClII, FeII, and FeIII; the S(0) through S(7) pure rotational lines of molecular hydrogen; the R(3) and R(4) transitions hydrogen deuteride (HD); several rotational transitions of water vapor; and the 6.2, 7.7, 8.6 and 11.3 micron PAH emission bands; all which have been detected in one or more sources that we have observed previously. Analysis of the resultant data will provide a wealth of information that will constitute an important legacy to interstellar medium science, probing - among other things - (1) the H2 ortho-to-para ratio, a valuable probe of the thermal history of the gas; (2) the HD abundance, from which the gas-phase D/H ratio can be determined ; (3) the water abundance, a key parameter that determines thermal balance in the shocked material; (4) the relative distribution of gas that has been heated by fast dissociative shocks and by slower non-dissociative shocks.

Spitzer Space Telescope - General Observer Proposal #30088

The physics of Runaway OB Star Bowshocks with Spitzer

Principal Investigator: Alberto Noriega-Crespo
Institution: Spitzer Science Center

Technical Contact: Alberto Noriega-Crespo, Spitzer Science Center

Co-Investigators:
Alejandro Raga, ICNUNAM
Jorge Canto, IAUNAM
Sean Carey, Spitzer Science Center
Dominic Clancy, Spitzer Science Center
Sachindev Shenoy, Spitzer Science Center

Science Category: ISM
Observing Modes: IracMap IrsStare MipsScan
Hours Approved: 19.1

Abstract:
Bowshocks from runaway OB stars are perhaps some of the most spectacular objects discovered by IRAS. The strong winds from these young stars can sweep relatively large column densities of gas and dust. This material accumulates in a bowshock that develops as the star moves supersonically through their surrounding medium. The dust and gas within the bowshock is illuminated by the starlight, which copiously reradiates this energy at mid/far infrared wavelengths. The large extent of these objects across the sky (~1/2 - 1 degree) plus the diffuse nature of their emission has prevented any major progress in understanding their properties since IRAS. Spitzer's unique capability to map large regions of the sky, and the superb sensitivity of its spectrometer to obtain spectra of diffuse emission at a fraction of a MJy/str, will be used to study five prototypical runaway bowshocks. These observations will be used to measure their IR bolometric luminosity, the emission properties of the shocked excited gas, the reprocessing of dust by shocks, the development of dynamical instabilites, and to provide observational templates to understand similar new objects found in the GLIMPSE and MIPSGAL surveys of the Galactic plane.

Spitzer Space Telescope - General Observer Proposal #20612

Si and Fe abundance study in star-forming regions

Principal Investigator: Yoko Okada
Institution: University of Tokyo

Technical Contact: Yoko Okada, U. Tokyo

Co-Investigators:
Takashi Onaka, University of Tokyo
Hiroshi Shibai, Nagoya University
Hidenori Takahashi, University of Tokyo
Takashi Miyata, University of Tokyo
Yoshiko K. Okamoto, Ibaraki University
Itsuki Sakon, University of Tokyo

Science Category: ISM
Observing Modes: IrsMap IrsStare
Hours Approved: 23.8

Abstract:
We propose to examine the depletion of Si and Fe in HII regions and reflection nebulae with IRS LH and SH module. We will observe the [SiII] 35 micron and [FeII] 26 micron emissions to estimate the gas-phase abundance of Si and Fe, which reflect the dust destruction in the observed region. Other lines such as [FeIII] 23 micron, [FeII] 18 micron, and [SIII] 19 and 33 micron can be used to translate safely the ratio of the line emissions to the abundance ratio. We plan to observe two groups of targets: (a) HII region/PDR complexes or reflection nebulae studied by ISO or KAO, and (b) giant HII regions located at various location in the Galactic plane. For the group (a) targets, we will derive gas-phase Si and Fe abundance relative to N or O in the HII region or PDR, respectively, giving the degree of the destruction of Si-bearing and Fe-bearing dust grains in each phase. For the group (b) targets, we will derive the relative gas phase abundance of Si/Fe. The proposed observations will be the first study of the Fe depletion in low density regions. They also provide the depletion pattern of Si/Fe in various environments such as the density and the phase (HII region or PDR) over the Galactic scale and give us significant observational constraint on the dust processing in the ISM and the dust model.

Spitzer Space Telescope - Archive Research Proposal #50077

Spitzer characterization of dust grains in regions of anomalous emission

Principal Investigator: Roberta Paladini
Institution: Spitzer Science Center

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Co-Investigators:
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Sean Carey, Spitzer Science Center
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Science Category: ISM
Dollars Approved: 50000.0

Abstract:
Despite the increasing evidence that the anomalous emission is a new physical mechanism acting in the diffuse interstellar medium, the nature and distribution of this component remains elusive. In particular, the infrared properties of the sources which, to date, are known to exhibit microwave excess, are very poorly known mostly due to the limited angular resolution and frequency coverage of DIRBE and IRAS. We propose to analyze archival observations of anomalous emission regions in order to characterize the typical dust population and environment, in particular the grain size, grain constituents and radiation field hardness, in these regions. A search in the Spitzer archive has revealed that almost the entirety of the objects with signatures of anomalous emission have been observed by its instruments. In addition, Spitzer data, with their unique combination of high resolution, sensitivity and wide spectral coverage, provide a unique tool for investigating the physical properties of dust in these sources. Such characterization will allow to put tight constraints on the existing models and provide new predictions on the level of contamination expected in future CMB experiments.

Spitzer Space Telescope - General Observer Proposal #20129

Ice Chemistry in IC 5146 : A Follow-Up Study of Dense Cloud Dust

Principal Investigator: Yvonne Pendleton
Institution: NASA Ames Research Center

Technical Contact: Yvonne Pendleton, NASA Ames Research Center

Co-Investigators:
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Rachel Mason, Gemini South
Charlie Lada, CfA
Adwin Boogert, CalTech
Michael Werner, JPL
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Dale Cruikshank, NASA-Ames
Jesse Bregman, NASA-Ames

Science Category: ISM
Observing Modes: IrsStare
Hours Approved: 5.0

Abstract:
We propose higher S/N 5.3-14.2 micron IRS spectra of 6 of our Cycle 1 background field star targets which sample quiescent dust in the dense cloud IC 5146. This cloud has the best-understood dust distribution of the four clouds under study in our Cycle 1 proposal. Our Cycle 1 clouds range from a starless Bok Globule to clouds with a small degree of low mass star formation. IC 5146 is exceptionally well characterized making this an ideal testbed to study interstellar dust. Our Cycle 1 data for 12 sightlines reveals silicate features in all cases, and variations in the ice to silicate band ratios. Although well matched flux values can be achieved using the newly discovered extinction law for diffuse dust (Indebetouw et al. 2005), the laws previously thought to apply to dense clouds overestimated the 6 um flux. Thus, our Cycle 1 integration times (I.T.) were low for these sightlines. We request 5 hours I.T. on IRS to obtain higher S/N data for this very important cloud. Because the dust distribution is so well characterized in this cloud, these observations will allow us to probe the early stages of chemical processing of dense cloud dust to an unprecedented degree. This cloud is critical in the continuum of clouds we selected for Cycle 1. Positions and profiles of the 6.0 ?m and 6.8 ?m ice features in our IC 5146 lines of sight will allow us to identify the principal components of 'quiescent' cloud ices in the absence of stellar activity, and to assess how dense cloud materials evolve as they pass from the general cloud medium into star-formation regions.

Spitzer Space Telescope - General Observer Proposal #3320

Solid State Chemistry in Dense Clouds Along Quiescent Lines of Sight

Principal Investigator: Yvonne Pendleton
Institution: NASA Ames Research Center

Technical Contact: Yvonne Pendleton, NASA Ames Research Center

Co-Investigators:
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Rachel Mason, NOAO
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Scott Sandford, NASA Ames Research Center
Alexander Tielens, University of Groningen
Alan Tokunaga, University of Hawaii

Science Category: ISM
Observing Modes: IrsStare
Hours Approved: 25.9

Abstract:
We propose 5.3-21.8 um spectroscopic observations of background field stars along sight-lines through dense interstellar clouds, with little or no star formation activity, to assess the early chemistry of molecular cloud dust. Dense clouds produce molecules and ices critical to star and planet formation. The formation of organic compounds in these ices is one of the first steps towards the complex molecular materials needed for life. Infrared spectroscopy provides a powerful tool for the study of the composition and evolution of interstellar ices. The most diagnostic features of solid-state materials occur in the mid-infrared. To date, mid-IR absorption studies have primarily been towards embedded protostars where the ice may well have been processed either thermally or by FUV photons from the star. Such sightlines demonstrate a preponderance of simple molecules (H2O, CH3OH, CO, CO2, and NH3) and energetically processed species (X- CN) in the surrounding ices, revealing that protostars strongly influence their circumstellar environments. Lines of sight to these objects are unlikely to be representative of dense cloud materials as a whole. A more complete understanding of the composition of dense clouds and their chemical dynamics requires that we also probe lines of sight through the general quiescent cloud medium. We will obtain low resolution IRS spectra (including 6.0 um H2O, 6.85 um NH4+/CH3OH, 7.6 um CH4, and 15.2 um CO2 band), plus high resolution IRS spectra for selected high AV sources, to study detailed band profiles. We will correlate band strengths with Av to determine the abundances and densities required for the ice components to appear, and study the chemical changes in molecular clouds as a function of temperature and density. These observations will provide a snapshot of the chemical state of a molecular cloud prior to the formation of stars, and a general baseline for studies of dust chemistry in regions of star formation.

Spitzer Space Telescope - General Observer Proposal #50637

Interactions of the Cold and Hot ISM: Imaging the Nearest Molecular Clouds In the Local Bubble

Principal Investigator: Seth Redfield
Institution: McDonald Observatory, University of Texas

Technical Contact: Seth Redfield, McDonald Observatory, University of Texas

Co-Investigators:
James Ingalls, Spitzer Science Center
John Scalo, University of Texas at Austin
Paul Harvey, University of Texas at Austin

Science Category: ISM
Observing Modes: IracMap MipsScan
Hours Approved: 9.6

Abstract:
The absolute nearest molecular clouds reside within a million degree substrate known as the Local Bubble. Cold molecular gas is not typically found in isolation surrounded by hot material, but several other examples have been identified, particularly at the edges of shell structures formed by stellar winds and supernovae. These local molecular clouds located within the Local Bubble, provide a unique opportunity to study the interaction of cold and hot phases of the interstellar medium in detail. We propose a morphological study of MBM40, one the nearest molecular clouds at <80 pc, to test predictions of evaporative conduction and turbulent mixing layer theory. The morphology of these translucent clouds, measured with physical resolutions down to <100 AU due to their proximity, can be probed by 8 micron PAH emission and dust emission from the longest MIPS wavelengths (e.g., 24 and 160 microns). These observations will measure basic physical properties, such as dust opacity and temperature, as well as, gas column density. Constraints on evaporative timescales and magnetic field strengths can be estimated from the dimensions of the smallest observed size scales. In addition, these measurements may even provide limits on the physical characteristics of the hot gas itself. The proposed cloud (MBM40) is distinct from the more distant large molecular complexes because it is located within the hot Local Bubble cavity which defines the bounds of our local interstellar medium. These observations will be a unique contrasting sample to the well-observed, and more distant, traditional molecular clouds.

Spitzer Space Telescope - General Observer Proposal #40604

"Quasi-Historical" Type Ia Supernova Remnants in the Large Magellanic Cloud: "Massive" Ia's and Dust Destruction

Principal Investigator: Stephen Reynolds
Institution: North Carolina State University

Technical Contact: Stephen Reynolds, North Carolina State University

Co-Investigators:
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William Blair, Johns Hopkins University
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Sean Hendrick, Millersville University
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John Raymond, Harvard-Smithsonian Center for Astrophysics
Chris Smith, CTIO
Sean Points, CTIO
Frank Winkler, Middlebury College
Kazimierz Borkowski, North Carolina State University

Science Category: ISM
Observing Modes: IrsMap IrsPeakupImage IrsStare
Hours Approved: 5.9

Abstract:
Type Ia supernovae and their remnants play a major role in several areas of astrophysics, including chemical evolution of galaxies and cosmology. Recent results suggest that at least some SNe Ia may result from more massive progenitor systems than normally assumed. Historical SN Ia in our Galaxy, SN 1006, Tycho, and Kepler, with known ages and optically observed shock velocities, have provided important information on the SN Ia phenomenon; Kepler seems to have resulted from a "massive" Type Ia. Three SNRs in the LMC have ages estimated from light echos, so they are "quasi-historical." N103B is interacting with dense, probably circumstellar material (CSM), like Kepler; 0509-67.5 has inferred efficient cosmic-ray acceleration; and the spectrum of the light echo from 0519-69.0 resembles that of the overluminous Type Ia event SN 1991T. In all cases, simply learning the ambient density can provide crucial information. Furthermore, all three objects have very fast shocks which can serve as laboratories for the study of grain destruction. We propose spectral mapping of all three with LL in both orders, and pointings at bright knots in N103B with SL. With our models of dust heating and sputtering in shocks, we can use this information to deduce ambient densities and to test the models. For the bright knots in N103B, probably CSM, we may obtain composition information of significance for constraining the nature of the progenitor.

Spitzer Space Telescope - General Observer Proposal #30585

Spectroscopy Survey of Supernova Remnants in the Inner Galaxy

Principal Investigator: Jeonghee Rho
Institution: Caltech

Technical Contact: Jeonghee Rho, Caltech

Co-Investigators:
William Reach, Caltech
Jack Herwit, Northwestern University
Achim Tappe, SSC/Caltech
Tom Jarrett, SSC/Caltech
Farhad Yusef-zadeh, Northwestern University

Science Category: ISM
Observing Modes: IrsStare MipsSed
Hours Approved: 18.7

Abstract:
In the infrared, supernova remnants (SNRs) have recently been found (with GLIMPSE Legacy data covering 95 known SNRs) to comprise three major groups: molecular-line dominated, ionic-line dominated, and PAH-like. Many of the 18 IRAC-detected SNRs show molecular-line colors, indicating interactions with dense gas, for which most of the shock cooling occurs through molecular ro-vibrational lines. Such molecular SNRs have been long expected for Type II supernovae near molecular clouds, but only a few are known. Our understanding of the infrared emission from SNRs is limited with the broad-band IRAC images, because SNRs are line-dominated but with a continuum. Infrared spectroscopy is crucial to understanding physical processes such as shock physics, grain destruction and chemical processes behind strong SN shocks, and metal enrichment in interstellar gas. We propose IRS and MIPS-SED observations of 14 IRAC-detected SNRs. Our scientific goals are (i) to uncover the nature of the infrared emission of each SNR, (ii) to truly identify the SNRs that are interacting with molecular clouds, by detecting shocked H_2 emission, (iii) to study the excitation rates of H_2 lines, and shock physics, and finally, (iv) to investigate dust destruction and coupling between the dust and gas through the shocks.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30571

Tomographic imaging of IR echoes around Cas A - Spitzer's unique view on the 3-D structure of the ISM

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: Oliver Krause, University of Arizona

Co-Investigators:
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Stephan Birkmann, Max-Planck-Institut fuer Astronomie
Fabian Heitsch, Universitaets-Sternwarte Muenchen
Remy Indebetouw, University of Wisconsin
Barbara Whitney, Space Science Institute
Kelsey Johnson, University of Virginia

Science Category: ISM
Observing Modes: MipsPhot MipsScan
Hours Approved: 11.0

Abstract:
We propose to use 11h of MIPS guaranteed time to re-image infrared echoes around the prototypical supernova remnant Cassiopeia A which have been recently discovered by our team. Combining these new observations with our previous maps opens up the unprecedented opportunity to map the three-dimensional structure of the general interstellar medium around Cas A with high spatial resolution. This unique insight to the structure of the ISM will provide new constraints for models of turbulence and fragmentation of interstellar material. In addition, the structure of the ISM is an important input to radiative transfer models for obscured sources, which we will work to improve.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40167

Infrared Echoes and the Structure of the ISM

Principal Investigator: George Rieke
Institution: University of Arizona

Technical Contact: George Rieke, University of Arizona

Co-Investigators:
Yeunjin Kim, University of Arizona
Oliver Krause, Max Planck Institut/Heidelberg

Science Category: ISM
Observing Modes: MipsPhot
Hours Approved: 4.0

Abstract:
We propose to continue a program to map the interstellar medium in three dimensions. Our technique uses infrared echoes from the supernova Cas A, which we discovered during In-Orbit Checkout. We have observed the echoes every six months since, observing the changes in the patterns of heated dust as the light pulse from the supernova propagates through the surrounding ISM. We have developed methods to invert this series of snapshots of planes in the ISM into three dimensional images. By the end of the Spitzer mission, our 3D images will have a depth of 1.5pc at a resolution of about 0.1 pc. This detailed information about the structure of the ISM will have important applications in understanding extinction in dense regions, the radiative transfer and heating of such regions, and in how the ISM fragments, for example to form stars.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50322

Conditions in a supernova/molecular cloud shock interface

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: George Rieke, The University of Arizona

Co-Investigators:
Oliver Krause, Max Planck Institut fur Astronomie, Heidelberg
Yeunjin Kim, University of Chicago

Science Category: ISM
Observing Modes: IrsStare
Hours Approved: 9.0

Abstract:
The interfaces where supernova remnant shocks encounter molecular clouds are of great interest for the complex processing of the interstellar medium that occurs within them. They are also thought to be the sites of relativistic particle acceleration. Observations of these regions have been obtained previously with both ISO and Spitzer. However, in these examples, the geometry of the interface results in the various shock layers being projected onto each other on the sky (and onto the supernova remnant itself). We have identified such an interface at the northern edge of Cas A, but in this case the interface lies along the sky and the various layers - in situ accelerated electrons (synchrotron emission), thermal emission by dust (24 microns) and molecular gas (CO) are well resolved and separated from each other on the sky. We propose to scan across this region taking IRS high resolution spectra. We expect to map out the distribution of high- and low-ionization potential fine structure lines, thought to map shock regions of high and moderate velocity, as well as tracing molecular hydrogen in the low velocity shocks into the molecular cloud itself. We can also determine where and under what conditions the dust is destroyed in this interface. These observations will test shock models in a unique way, possible only in this unique observing situation.

Spitzer Space Telescope - General Observer Proposal #50484

Mapping the ISM with Infrared Echoes from Cas A

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: George Rieke, The University of Arizona

Co-Investigators:
Oliver Krause, Max Planck Institut fur Astronomie, Heidelberg
Yeunjin Kim, University of Chicago

Science Category: ISM
Observing Modes: MipsPhot MipsScan
Hours Approved: 14.9

Abstract:
Infrared echoes were discovered around the supernova remnant Cas A during Spitzer in-orbit checkout. These echoes result when the light pulse from the supernova explosion encounters the surrounding interstellar medium (ISM) and scatters and heats it. The infrared echoes are more easily interpreted than the scattered ones because the emission is isotropic and gives a direct measure of the structure of the ISM. The system of echoes around Cas A extends to 3 degrees diameter, so the MIPS 24 micron beam of 6 arcsec allows probing the echoes at high resolution. We have followed these echoes throughout the mission (using a combination of GTO, GO, and DD time). A preliminary analysis of the results has yielded the first detailed three dimensional map if the ISM (resolution ~ 0.1 pc on the sky corresponding to the beam size, and also ~ 0.1 pc into the sky corresponding to the Spitzer visit time intervals). We have also used the echoes to learn about the supernova itself. We request 14.9 hours to complete tracking the echoes. We will obtain a full map of the echo region to improve our ability to distinguish the echoes from the emission of the general ISM and to extend our images to the lowest possible spatial frequencies. We will also obtain three sets of smaller-scale images at selected regions to continue tracking the small-scale structures and also to improve our measurements of the supernova light curve.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #45

Deuterium Enrichment in PAHs

Principal Investigator: Thomas Roellig
Institution: NASA Ames Research Center

Technical Contact: Thomas Roellig, NASA Ames Research Center

Science Category: ISM
Observing Modes: IrsStare
Hours Approved: 37.3

Abstract:
Laboratory studies have indicated that under interstellar radiation condition the hydrogen atoms in PAH molecules will be replaced in time by deuterium. This investigation will gather evidence for this process by examining the PAH spectral features in a number of regions with quite different ages, ranging from proto-planetary nebulae, through planetary nebulae of various ages, on out to older PAH material in molecular clouds. The presence of deuterium in the PAH molecules dramatically shifts the locations of the spectral features, so that they can be detected with the IRS instrument. Since these objects are generally extended and sensitivity to very weak features is needed, observations will be made both on the targets and on nearby background sky.

Spitzer Space Telescope - General Observer Proposal #20068

IRAC Colors of Reflection Nebulae Illuminated by Cool Stars

Principal Investigator: Kris Sellgren
Institution: Ohio State University

Technical Contact: Kris Sellgren, Ohio State University

Co-Investigators:
Mike Werner, JPL
Keven Uchida, Cornell University

Science Category: ISM
Observing Modes: IracMap
Hours Approved: 20.3

Abstract:
We propose to obtain IRAC images of reflection nebulae (RN) illuminated by cool stars (Teff = 3,000 - 9,400 K). Our IRAC measurements of six RN will complement existing IRAC images of RN illuminated by B stars (Teff=11,000-22,000 K). In our previous IRAS study of RN illuminated by stars with Teff = 3,000 - 22,000 K, we contrasted the IRAS colors of RN illuminated by B stars and cool stars. Our results led to major advances in our understanding of the ISM, inspiring laboratory and theoretical work on PAH ionization and on the size distribution of PAH molecules and aromatic grains. Current ISM models, fit to our IRAS observations of RN, still find some RN illuminated by cool stars to disagree with model predictions. These discrepant RN form the heart of this proposal. Spitzer offers us vast improvements in sensitivity and angular resolution. Our entire IRAS sample of RN illuminated by B stars has been already imaged with IRAC. We now propose to obtain IRAC colors for RN illuminated by cool stars, to contrast with RN illuminated by B stars. We expect our Spitzer results to challenge current ISM models and to influence the development of new ISM models in the same way our IRAS results did.

Spitzer Space Telescope - General Observer Proposal #40276

Search For C_60

Principal Investigator: Kris Sellgren
Institution: Ohio State University

Technical Contact: Kris Sellgren, Ohio State University

Co-Investigators:
Michael Werner, Jet Propulsion Laboratory, California Institute of

Science Category: ISM
Observing Modes: IrsStare
Hours Approved: 14.7

Abstract:
We propose to follow up on our recent Spitzer IRS-LL2 detection of emission at 17.4 and 18.9 um in the reflection nebulae NGC 2023 and NGC 7023. These wavelengths coincide with two of the four infrared lines of buckminsterfullerene, or C_60. Our goal is to obtain IRS-SL spectra to confirm this identification by searching for the two other infrared C_60 lines, at 7.1 and 8.5 um. We will also obtain IRS-SH spectra to measure the widths of the 17.4 and 18.9 um lines, which depend on temperature for C_60.

Spitzer Space Telescope - General Observer Proposal #3295

Environmental Effects of Starbursts at the Galactic Center

Principal Investigator: Janet Simpson
Institution: NASA Ames Research Center

Technical Contact: Janet Simpson, NASA Ames Research Center

Co-Investigators:
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Sean Colgan, NASA Ames Research Center
David Hollenbach, NASA Ames Research Center
Michael Kaufman, San Jose State University
Robert Rubin, NASA Ames Research Center
Edwin Erickson, NASA Ames Research Center

Science Category: ISM
Observing Modes: IrsMap IrsStare
Hours Approved: 13.1

Abstract:
We propose infrared spectroscopic observations of the Galactic Center (GC) region of the Milky Way with the Infrared Spectrograph (IRS) on Spitzer Space Telescope. These observations will elucidate the character of the GC's massive star clusters and their effects - via both emitted radiation and outflowing winds - on the local interstellar medium (ISM) at the GC. The IRS enables access to a variety of infrared spectral signatures of the relevant processes - photoexcitation, shocks, photodissociation, and dust heating and extinction - which can clarify our understanding of the complex processes occurring at the heart of our own, and likely other, galaxies. Specific questions to be addressed are: -Are observable shocks due to outflows from the massive cluster stars or to collisions of molecular clouds? -Which of the radio structures are really related to the compact star clusters, as suggested by the observed morphology and how can we explain the structures not so related? -How does the gas excitation seen in the IR lines in the Arches Cluster correlate with the X-ray morphology, and can any excitation feature be identified with cluster WR stars?

Spitzer Space Telescope - General Observer Proposal #40299

IRS Spectral Mapping of Interstellar Ices, Silicates and Gas-phase CO2

Principal Investigator: Paule Sonnentrucker
Institution: Johns Hopkins University

Technical Contact: Paule Sonnentrucker, Johns Hopkins University

Co-Investigators:
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Perry Gerakines, University of Alabama
Eduardo Gonzalez-Alfonso, University of Madrid
Gary Melnick, Smithsonian Astrophysical Observatory
David Neufeld, Johns Hopkins University
Sarah Ragan, University of Michigan
Volker Tolls, Smithsonian Astrophysical Observatory
Dan Watson, University of Rochester
Doug Whittet, Rensselaer Polytechnic Institute

Science Category: ISM
Observing Modes: IrsMap
Hours Approved: 58.0

Abstract:
Ices remain one of the least understood components of the interstellar medium. Yet, ice covered dust grains may be a medium within which chemical reactions take place that have no analog in the gas-phase. The wavelength coverage and great sensitivity of Spitzer/IRS offer an opportunity to revolutionize the study of interstellar ices as the 5 to 38 micron range includes a number of ice absorption features such as water ice and CO2 ice. The high resolution mode of the IRS instrument is also capable of observing gas-phase CO2 features along identical sight lines where CO2 ice is detected. We propose to obtain fully sampled spectral maps of the distribution of CO2 ices, gas-phase CO2, water ice and silicates toward a sample of 6 extended regions selected for their variety of physical conditions. These proposed maps will constitute an enormous improvement over previous discrete sight line studies since they will increase the density of sampled points by orders of magnitude. We will use this unparalleled observational database to elucidate the key environmental factors that influence interstellar ice formation, evolution and destruction, thereby affecting the formation and/or destruction of gas-phase CO2 itself.

Spitzer Space Telescope - General Observer Proposal #20620

H2 shocks in the precessing outflow V380 Ori NE

Principal Investigator: Thomas Stanke
Institution: Institute for Astronomy, University of Hawaii

Technical Contact: Thomas Stanke, IfA, U. Hawaii

Co-Investigators:
Michael D. Smith, Armagh Observatory, UK
Chris Davis, Joint Astronomy Center Hawaii, Hilo
Hans Zinnecker, Astrophysikalisches Inst. Potsdam
Roland Gredel, Max-Planck Institut fuer Astronomie Heidelberg
Karl Menten, Max-Planck Institut fuer Radioastronomie Bonn
Dieter Nuernberger, ESO
Mark McCaughrean, AI Potsdam; Univ. of Exeter

Science Category: ISM
Observing Modes: IracMap IrsMap IrsPeakupImage
Hours Approved: 8.9

Abstract:
We propose to perform a IRAC imaging and IRS low-resolution spectroscopic mapping investigation of the precessing molecular jet and outflow V380 Ori NE. The main goal will be to investigate the effect of precession on the shape of the outflow cavity (mainly IRAC imaging) and on the interaction with the ambient cloud. We will obtain maps showing the spatial distribution of pure rotational transitions of H_2 and additional atomic/ionic forbidden lines. The H_2 lines will be used to study variations of excitation originating from changing shock properties, which we will pinpoint using detailed shock modeling and hydrodynamic molecular jet simulations. Combined with high-resolution CO maps we will see where entrainment takes place, how efficient it is, and how much of the parent cloud volume is affected. We will study the implications in terms of feedback (how efficient is the energy transfer to the ambient cloud), in terms of effects on protostar evolution (how significant is the effect of jet precession on envelope removal), and on shaping protostellar outflows themselves. Finally, we will study the effect of a molecular outflow suddenly breaking out into a low density, potentially (partly) ionized medium.

Spitzer Space Telescope - General Observer Proposal #40166

The circumstellar - interstellar interface revealed

Principal Investigator: Robert Stencel
Institution: University of Denver

Technical Contact: Robert Stencel, University of Denver

Co-Investigators:
Toshiya Ueta, University of Denver
Angela Speck, University of Missouri
Chris Wareing, University of Manchester, UK
Albert Zijlstra, University of Manchester, UK
Mikako Matsuura, National Astronomical Observatory of Japan

Science Category: ISM
Observing Modes: IrsMap MipsSed
Hours Approved: 2.4

Abstract:
With the discovery by Spitzer of a bow shock structure around the AGB star, R Hydrae, a new class of circumstellar - interstellar interaction physics is open to exploration. We propose IRS and MIPS-SED spectroscopy of the bow shock structure around R Hya. The goal of the spectroscopy is to provide temperature and density diagnostics for the material in the shocked region. These measurements will provide context for analysis of variation of mass loss and gas to dust ratio, as well as exploration of the destruction of circumstellar dust at this well-defined interstellar boundary.

Spitzer Space Telescope - Directors Discretionary Time Proposal #532

Tie Breaking Spectra of the Dusty Bow Shock Near R Hya

Principal Investigator: Robert Stencel
Institution: University of Denver

Technical Contact: Robert Stencel, University of Denver

Co-Investigators:
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Mikako Matsuura, U. College London
Angela Speck, U. Missouri
Albert Zijlstra, Manchester

Science Category: ISM
Observing Modes: IrsMap
Hours Approved: 0.5

Abstract:
We request 30 minutes of Director's Discretionary Time for an urgent, tie-breaking IRS observation of the first-ever, Spitzer-MIPS discovered, circumstellar-interstellar bow shock surrounding the AGB star, R Hydrae.

Spitzer Space Telescope - General Observer Proposal #3677

High Resolution Imaging of the Galactic Center with Spitzer/IRAC

Principal Investigator: Susan Stolovy
Institution: Spitzer Science Center

Technical Contact: Susan Stolovy, Spitzer Science Center

Co-Investigators:
Daniel Gezari, GSFC
Solange Ramirez, Spitzer Science Center
Jennifer Karr, Spitzer Science Center
Rick Arendt, GFSC
Farhad Yusef-Zadeh, Northwestern University
Casey Law, Northwestern University
Kristen Sellgren, Ohio State University
Randall Smith, CfA
Harvey Moseley, GSFC

Science Category: ISM
Observing Modes: IracMap
Hours Approved: 15.7

Abstract:
The Spitzer Space Telescope provides an unprecedented opportunity to observe the Galactic Center with spatial coverage, resolution and sensitivity which have not yet been achieved in the mid-infrared. We propose to map the central 2 x 1.5 degrees of the Galaxy (corresponding to 280 x 200 pc) with IRAC. These observations will allow us to investigate features in the diffuse interstellar medium of the Galactic Center ranging in scale from hundreds of pc to less than 0.1 pc. These features include large 'lobes' protruding from the Galactic plane, non-thermal filaments, thermal filaments, supernova remnants and HII regions, some of which may trace past AGN-like activity. The morphology and distribution of PAH emission will be imaged at 2'' resolution for the first time with high signal/noise. The acquisition of high resolution mid-IR data will complement existing high resolution data for this region in radio, near-infrared and X-ray wavelengths and will provide a probe of interactions and phenomena at a wide range of energies. In addition, a variety of point sources and compact objects will be observed, taking advantage of the IRAC wavelengths to probe regions too highly obscured to observe with ground based optical or near infrared telescopes. We will acquire a sample of AGB and OH/IR stars, detectable even in highly obscured regions, as well as high mass protostars and ultracompact HII regions, probing both ends of the stellar evolution process and mapping galactic structure. We will also have the ability to detect obscured clusters not visible in the near infrared.

Spitzer Space Telescope - General Observer Proposal #30372

Polycyclic Aromatic Hydrocarbon Emission in the Supernova Remnant N132D

Principal Investigator: Achim Tappe
Institution: IPAC / Spitzer Science Center

Technical Contact: Achim Tappe, IPAC / Spitzer Science Center

Co-Investigators:
Jeonghee Rho, IPAC / Spitzer Science Center
William T. Reach, IPAC / Spitzer Science Center
Christine Joblin, CESR, Toulouse, France

Science Category: ISM
Observing Modes: IrsMap IrsStare
Hours Approved: 11.0

Abstract:
The infrared spectrograph (IRS) onboard the Spitzer Space telescope allows to observe mid-IR continuum emission from heated interstellar dust grains and polycyclic aromatic hydrocarbon (PAH) emission lines. These include the well-studied PAH lines at 6-9 and 11.2 micron, and the more recently detected emission in the 15-21 micron region attributed to CCC out-of-plane bending vibrations. Our previous GO-1 observations of the supernova remnant N132D in the Large Magellanic Cloud were very successful. The detected PAH features between 8 and 20 microns demonstrate that PAH molecules are surviving a supernova blast wave despite being processed by a strong shock. This second proposal will enlarge our IRS data for this interesting remnant substantially, from currently one spectral pointing to a complete IRS 14-38 micron map with additional IRS 5.2-14.5 micron pointings for regions of special interest. This will allow us to study the distribution and shock processing of PAHs in detail, particularly the intriguing 15-21 micron features, using existing spectral databases and new laboratory as well as theoretical work.

Spitzer Space Telescope - General Observer Proposal #50511

The relationship of PAHs and H2 emission in the photodissociation region of the reflection nebula NGC 2023

Principal Investigator: Alexander Tielens
Institution: NASA Ames Research Center

Technical Contact: Alexander Tielens, NASA Ames Research Center

Co-Investigators:
Els Peeters, The University of Western Ontario; SETI Institute
Mark Wolfire, University of Maryland
Louis Allamandola, NASA Ames Research Center

Science Category: ISM
Observing Modes: IrsMap
Hours Approved: 3.4

Abstract:
The mid-IR spectra of photodissociation regions (PDRs) are dominated by the diagnostic lines of molecular hydrogen as well as the 3.3, 6.2, 7.7, 11.3, and 12.7 um emission features due to polycyclic aromatic hydrocarbon molecules (PAHs). The molecular hydrogen lines are key diagnostics of the temperature and column density of warm molecular gas in the PDR, while the relative strength of the IR emission features probe the molecular edge structure and degree of ionization of the emitting PAHs. Previous Spitzer studies of the warm and dense southern PDR shell in the reflection nebula NGC2023 have demonstrated that the detailed characteristics of the IR emission features vary between the atomic H surface layer of this region and the deeper molecular H2 layers. We attribute these variations to H abstraction by reactive atomic H in this surface layer forming H2. We propose to use the superb sensitivity and high spatial resolution of the IRS on Spitzer to spectroscopically map a lower density region in this reflection nebula with the goal of quantifying the dependence of the IR emission characteristics of the emitting PAHs to the local physical conditions. Specifically, we will address the role of atomic H in the loss of peripheral aromatic H on interstellar PAHs. The selected location has a well-determined gas density and temperatureand incident UV field, which ultimately drive the physical and chemical characteristics of the emitting PAHs and hence provide a unique opportunity to quantitatively study the evolution of PAHs in space as well as the role of PAHs in the formation of molecular hydrogen.

Spitzer Space Telescope - General Observer Proposal #40285

The Composition of Interstellar Dust

Principal Investigator: Laurens Waters
Institution: University of Amsterdam

Technical Contact: Laurens Waters, University of Amsterdam

Co-Investigators:
Xander Tielens, NASA Ames Research Center
Mario van den Ancker, European Southern Observatory, Garching
Michiel Min, University of Amsterdam
Leen Decin, Institute for Astronomy, Catholic University Leuve
Jolanda van Breemen, University of Amsterdam
Ciska Markwick-Kemper, Dept. of Physics and Astronomy, Manchester Univers
Arjan Bik, European Southern Observatory, Garching
Jean Chiar, SETI Institute and NASA Ames research center
Jan Cami, Dept. of Physics and Astronomy, University of West

Science Category: ISM
Observing Modes: IracMap IrsStare
Hours Approved: 21.0

Abstract:
We propose to determine the life cycle of two important refractory stardust species, one oxygen-rich and one carbon-rich, in order to probe the fate of stardust from the time of injection into the ISM up to the point that it takes part in the star formation process. Crystalline silicates and SiC are produced in the outflows of evolved red giants. Recently for the first time evidence was found for SiC in the interstellar medium (ISM), suggesting that this material can survive the harsch ISM conditions. In contrast, crystalline silicates, produced by oxygen-rich giants, have so far not been found in the ISM. In our solar system, crystalline silicates are abundant while SiC is not. Therefore, crystalline silicates must be re-formed in the star formation process, while SiC is destroyed in the same process. Establishing abundances of both materials in the diffuse ISM and molecular clouds will determine the way in which these materials are processed. High quality observations, supplementing archival Spitzer data, are needed to obtain abundances of these dust species. We propose to observe a sample of highly reddened stars that probe the dust composition in their line of sight.

Spitzer Space Telescope - Theoretical Research Proposal #20109

Optical Properties of Cosmic Dust Materials

Principal Investigator: Joseph Weingartner
Institution: George Mason University

Technical Contact: Joseph Weingartner, George Mason University

Co-Investigators:
Gary Ferland, University of Kentucky

Science Category: ISM
Dollars Approved: 48191.0

Abstract:
Many cosmic dust materials exhibit identifying spectral features in the infrared, and laboratory work has provided detailed infrared optical properties for numerous materials of astrophysical importance. Thus, the Spitzer Space Telescope is a powerful tool for determining the grain constituents in a wide range of cosmic environments, including protoplanetary disks, outflows from evolved stars, supernovae, star-forming regions, and active galactic nuclei. Dust is important both in the physics of these objects and as a diagnostic. For example, dust absorbs short-wavelength radiation and re-emits at longer wavelengths, and often dominates the heating or cooling of the gas. Thus, detailed interpretation of the spectrum, originating in both gas and dust, is only possible if the optical properties of the dust materials are known across the entire electromagnetic spectrum. We propose to construct X-ray to far-infrared (FIR) dielectric functions for a host of important dust materials, consistent with all available constraints (from laboratory data, basic physical principles, and astronomical observations). These materials include a variety of silicates, oxides, and sulfides. The optical properties will be made available on the World Wide Web and will be incorporated into the spectral simulation code CLOUDY.

Spitzer Space Telescope - Archive Research Proposal #30054

The thermal evolution of ices in the environments of newly formed stars: Archival studies of the CO2 bending mode observed with the Spitzer IRS

Principal Investigator: Douglas Whittet
Institution: Rensselaer Polytechnic Institute

Technical Contact: Douglas Whittet, Rensselaer Polytechnic Institute

Co-Investigators:
Edwin Bergin, University of Michigan
Jean Chiar, SETI Institute
Amanda Cook, Rensselaer Polytechnic Institute
Perry Gerakines, University of Alabama at Birmingham
Erika Gibb, University of Missouri, St. Louis
Gary Melnick, Center for Astrophysics
David Neufeld, Johns Hopkins University
Sachindev Shenoy, Spitzer Science Center

Science Category: ISM
Dollars Approved: 64052.0

Abstract:
We propose research designed to increase our understanding of the thermal evolution of ices in the environments of deeply embedded young stellar objects (YSOs) of low to intermediate mass in the local galaxy. This is an important astrophysical goal because the ices are carriers of key chemical elements and compounds from interstellar clouds to protostellar envelopes and protoplanetary disks. It will be accomplished by means of a detailed study of the 15 micron feature of solid carbon dioxide in high-resolution IRS spectra of class 0 and class I YSOs from the Spitzer archive. Carbon dioxide is a ubiquitous constituent of the ices with abundance typically 20-30% relative to water; its 15 micron absorption profile is established as a tracer of the physical and chemical changes that occur when the ices are heated from typical molecular-cloud temperatures to those arising in the warmer envelopes of YSOs. We aim to build upon our previous work, which includes extensive observational programs with both ISO and SST, and NASA-funded studies of laboratory analogs in support of our Spitzer observations. Those observations (GTO program #27; cycle 1 GO program #3303) established the nature and abundance of CO2-bearing ices in cold, quiescent molecular clouds, results that provide ground-truth for comparison with the wealth of YSO spectra now available from the SST archive. A comprehensive study that will help define Spitzer's contribution to our understanding of ices in star formation regions is now warranted. Our prior experience with IRS data reductions and profile modeling, together with the availability of new results from our synergistic studies of laboratory analogs, will ensure that we fully extract the information inherent in these profiles.

Spitzer Space Telescope - General Observer Proposal #3303

The Evolution of Astrophysical Ices: The Carbon Dioxide Diagnostic

Principal Investigator: Douglas Whittet
Institution: Rensselaer Polytechnic Institute

Technical Contact: Douglas Whittet, Rensselaer Polytechnic Institute

Co-Investigators:
Edwin Bergin, University of Michigan
Jean Chiar, NASA Ames Research Center/SETI Institute
Perry Gerakines, University of Alabama at Birmingham
Erika Gibb, University of Notre Dame
Gary Melnick, Center for Astrophysics
David Neufeld, Johns Hopkins University
Sachindev Shenoy, Rensselaer Polytechnic Institute

Science Category: ISM
Observing Modes: IrsStare
Hours Approved: 39.6

Abstract:
We propose to use the Infrared Spectrometer on board the Spitzer Space Telescope to carry out a comprehensive study of the carbon dioxide bending-mode absorption feature centered near 15 microns in astrophysical ices. Previous observations with the Infrared Space Observatory, together with studies of laboratory analogs, have shown that this feature has strong diagnostic properties. Substructures within the feature are sensitive to the thermal history of the ices and to the formation of linked carbon dioxide/methanol complexes. Both of these molecules are important repositories for carbon and oxygen in interstellar ices, and their roles in the chemical evolution of the ices and their sublimation products are intimately linked. The abundance of carbon dioxide relative to methanol is a diagnostic of key reaction pathways, measuring the relative efficiencies of catalytic oxidation and hydrogenation reactions in cold dark clouds. In regions exposed to the interstellar radiation field, photolytic reactions may contribute to their formation. The distribution of carbon between these molecules may subsequently influence the production efficiencies of more complex organic molecules in regions of active star formation, where the ices are subject to heating, irradiation and shocks. By studying a range of absorbers, from pristine ices in dark clouds to processed ices in the vicinity of embedded stars, we will build a clear picture of the evolution of ices from the interstellar medium to protostellar envelopes and protoplanetary disks.

Spitzer Space Telescope - General Observer Proposal #40432

Ices at the lowest temperatures: Spitzer IRS observations of Lynds 134N

Principal Investigator: Douglas Whittet
Institution: Rensselaer Polytechnic Institute

Technical Contact: Douglas Whittet, Rensselaer Polytechnic Institute

Co-Investigators:
Edwin Bergin, Univiersity of Michigan
Jean Chiar, SETI Institute
Amanda Cook, Rensselaer Polytechnic Institute
Perry Gerakines, University of Alabama at Birmingham
Erika Gibb, University of Missouri - St. Louis
Eric Herbst, Ohio State University
Sachindev Shenoy, Spitzer Science Center

Science Category: ISM
Observing Modes: IrsStare
Hours Approved: 13.6

Abstract:
Spitzer's Infrared Spectrograph is providing a vast library of spectra for young stellar objects (YSOs) of low and intermediate mass that remain embedded in placental material. Solid-state features of dust and ices are detected routinely in these spectra, prominent amongst them the carbon dioxide bending-mode absorption near 15 microns. This feature has strong diagnostic properties, with potential to yield insight into the chemical pathways that produce CO2 in different environments and the thermal evolution of the ices in the vicinity of young stars. However, to fully exploit this potential for interpretation of YSO spectra, it is essential to establish the nature of CO2-bearing ices in the coldest regions of molecular clouds, remote from shocks and radiation fields driven by embedded stars. This requires observation of ice features in the spectra of background field stars viewed through the dense material. Previous observations have provided a clear picture of the composition and structure of the ices in **one** dark cloud (Taurus), but it is not clear whether this cloud is prototypical: the only currently available comparison line of sight shows major differences. We propose the first detailed study of ices in L134N, a cold, chemically-rich, isolated globule that we believe to be an excellent test case of ambient conditions in the quiescent dark-cloud environment. Background stars are intrinsically faint in the mid-IR: the sensitivity and spectral coverage of Spitzer provide a unique opportunity to obtain high quality spectra for a significant sample of targets.

Spitzer Space Telescope - General Observer Proposal #20012

PAH Emission in the Giant H II Region RCW49

Principal Investigator: Mark Wolfire
Institution: University of Maryland

Technical Contact: Mark Wolfire, University of Maryland

Co-Investigators:
John Mathis, University of Wisconsin
Barbara Whitney, Space Science Institute
Remy Indebetouw, University of Virginia, Charlottesville

Science Category: ISM
Observing Modes: IrsMap
Hours Approved: 14.0

Abstract:
We use the giant H II region RCW49 as an astrophysical laboratory to improve our understanding of PAH emission and PAH emission models. If the broad emission features seen in the near and mid infrared are due to PAHs, then specific band ratios and band widths are predicted to change with local conditions. We use the high spatial resolution of Spitzer along with high sensitivity to create a series of IRS maps to test these models. In addition, we examine the variation in the PAH/continuum ratio to probe the small grain abundances. Since the entire region has been mapped by IRAC we will also directly measure the contribution by PAH and continuum emission to the IRAC [5.8] and IRAC [8.0] bands and we will predict the line emission in all IRAC bands from the longer wavelength line emission measured by the Spitzer IRS high resolution mode.

Spitzer Space Telescope - General Observer Proposal #30295

Tracking Warm H_2 in Photodissociation Regions

Principal Investigator: Mark Wolfire
Institution: University of Maryland

Technical Contact: Mark Wolfire, University of Maryland

Co-Investigators:
David Hollenbach, NASA Ames Research Center
Michael Kaufman, San Jose State University

Science Category: ISM
Observing Modes: IrsMap
Hours Approved: 23.0

Abstract:
Photodissociation regions (PDRS) include all regions of the interstellar medium in which far-ultraviolet photons play an important role in the chemistry or heating of the gas. These include HI clouds, the surfaces of molecular clouds illuminated by the interstellar radiation field, and molecular clouds illuminated by intense radiation from nearby massive stars. In general, models provide a good match to the observations, but several recent observations of H_2 and CO indicate that models underestimate the gas temperature. We propose to conduct IRS mapping observations of the warm H_2 in several PDRs. The high spatial resolution and sensitivity of Spitzer will allow us to test PDR models and determine if additional sources of heating are required. It is essential to understand the thermal processes in PDRs in order to use PDR models in comparison with data, to derive physical parameters in the ISM of our Galaxy, as well as external galaxies. In addition, we will use our data sets to improve our understanding of PAH emission and PAH emission models. If the broad emission features seen in the near and mid infrared are due to PAHs, then specific band ratios and band widths are predicted to change with local conditions. We use the high spatial resolution of Spitzer along with high sensitivity to create a series of IRS maps to test these models

Spitzer Space Telescope - General Observer Proposal #20611

The evolution of dust mineralogy in southern star forming clouds

Principal Investigator: Christopher Wright
Institution: Australian Defence Force Academy, University of

Technical Contact: Christopher Wright, Australian Defence Force Academy

Co-Investigators:
Marco Maldoni, Australian Defence Force Academy, University of Ne
Robert Smith, Australian Defence Force Academy, University of Ne

Science Category: ISM
Observing Modes: IrsStare
Hours Approved: 7.6

Abstract:
Planets form within the dusty circumstellar disks around young stars. Samples of the solid material composing our own primitive disk are found in meteorites and interplanetary dust particles. Using the powerful technique of mid-infrared spectroscopy via IRS on board Spitzer we will ascertain the composition of the material existing within the disks around young stars in several southern star forming regions. We will study a range of disks of varying ages around embedded, T Tauri, Herbig Ae/Be and Vega-type stars. In so doing we will determine how the dust composition evolves with time and/or environment, and what physical processes affect it, in order to better understand how our own solar system formed.

Spitzer Space Telescope - General Observer Proposal #30619

The water ice librational band in AFGL 961

Principal Investigator: Christopher Wright
Institution: Australian Defence Force Academy

Technical Contact: Christopher Wright, Australian Defence Force Academy

Co-Investigators:
Robert Smith, UNSW@ADFA

Science Category: ISM
Observing Modes: IrsStare
Hours Approved: 0.4

Abstract:
The only source "missing" from the ice band database observed by ISO is AFGL 961 in the Rosette Nebula. However, this is an extremely important object because it is also the only source for which the 13 micron water ice librational band has been claimed as identified, from an IRAS LRS spectrum. There are several potential problems with this identification, most notably its apparent uniqueness, but also the low S/N and low spatial and spectral resolution of the LRS spectrum. AFGL 961 is also a binary with separation of 6 arcsecs, which could have an impact on the spectral appearance when observed in the large IRAS beam. We therefore aim to settle once and for all the question of whether the librational band of water ice is present toward AFGL 961, and if so determine why it is so unique amongst its cousin massive and deeply embeded Young Stellar Objects.

Spitzer Space Telescope - General Observer Proposal #20414

A Large-scale Survey of the Galactic Center at 24 microns

Principal Investigator: Farhad Yusef-Zadeh
Institution: Northwestern University

Technical Contact: Farhad Yusef-Zadeh, Northwestern University

Co-Investigators:
George Rieke, University of Arizona
Joannah Joannah, University of Arizona
Casey Law, Northwestern University
Mark Wardle, University of McQuarie
Michael Burton, University of New South Wells

Science Category: ISM
Observing Modes: MipsScan
Hours Approved: 18.2

Abstract:
We request 18 hours of Spitzer time to make a large-scale (2x8 degrees) map of the Galactic Center Region at 24micron. This map will provide substantial gains in resolution and sensitivity over previous infrared data (IRAS, MSX, and ISO). Over most of the area (> 90%) we expect to achieve a 4-sigma point source detection limit of 1mJy. It is impossible to map this region to this depth in any other way. Given the unique advantages of the Galactic Center region for studying the phenomena in galaxy nuclei generally, it is inconceivable that the Spitzer}mission would be allowed to end without obtaining these data. They will become a part of the core legacy of the mission. We will use these measurements to take advantage of the unique physical resolution in the Galactic Center to compare with the behavior of the central regions of external galaxies. This comparison will include structures in the Galactic Center that have never been detected in other galaxies, but presumably are representative of what happens within them. Examples include the nonthermal filaments and the Galactic Center Lobe in the radio. The first implies that magnetic fields play a large role in shaping and controlling the interstellar medium, and the second appears to be a region of massive outflow. We will also determine an a more accurate estimate of dust temperature throughout this region and investigate its relationship with respect to the high neutral gas temperature found in this region. We will also study the clusters of massive stars and use the new data to identify additional examples. These studies will draw on the unique and large database available for this region in the radio and X-ray, much of which has been acquired by the PI working with various collaborators.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40051

Spectral Mapping of W49A

Principal Investigator: Bernhard Brandl
Institution: University of Leiden

Technical Contact: Bernhard Brandl, University of Leiden

Co-Investigators:
Edward Churchwell, University of Wisconsin-Madison
Dan Watson, University of Rochester
Jim Houck, Cornell University

Science Category: HII regions
Observing Modes: IrsMap
Hours Approved: 3.6

Abstract:
We propose to spectrally map the massive Galactic HII region W49A with Spitzer-IRS in low-resolution mode. W49A is one of the most luminous and prolific massive star formation regions in the disk of the Milky Way. W49A is unique among massive Galactic star forming regions in that it contains about 40 separate ultra-compact HII regions and several massive, evolved OB clusters, embedded in 10E6 solar masses of molecular gas -- all located within a region of about 55pc. Our previous IRAC observations have shown that these components are closely related. Here we propose to complete our 5-15um spectral map of the central part of W49A to study the dynamics, physics and chemistry in the core of a luminous starburst region at reasonably high spatial resolution. The results will be of great importance to study the formation of massive stars and their interplay with the surrounding ISM. Previous GTO observations have demonstrated the technical feasibility of this project but unfortunately missed (due to scheduling reasons) the most relevant part of the region.

Spitzer Space Telescope - General Observer Proposal #30205

PINNING DOWN THE CHEMICAL ABUNDANCES OF METAL-RICH GIANT HII REGIONS

Principal Investigator: Fabio Bresolin
Institution: University of Hawaii

Technical Contact: Fabio Bresolin, University of Hawaii

Co-Investigators:
Grazyna Stasinska, Observatoire de Paris-Meudon
Bernhard Brandl, Leiden Observatory
Daniel Schaerer, Observatoire de Geneve

Science Category: HII regions
Observing Modes: IrsStare
Hours Approved: 16.9

Abstract:
Measuring chemical abundances for giant extragalactic HII regions is crucial to understand the evolution of star-forming galaxies. Yet, there are lingering uncertainties regarding the techniques used for abundance determination at the high end of the metallicity scale (roughly solar and above). The so-called 'statistical' methods, used commonly for measuring abundances in nearby spirals as well as in high-redshift star-forming galaxies, provide oxygen abundances that are up to 2-3 times larger than those obtained from 'direct' methods in the case of metal-rich nebulae. This discrepancy affects a variety of studies on the nature of gaseous nebulae. In the past few years our group has collected Keck and VLT optical spectra of metal-rich HII regions in spiral galaxies with the purpose of deriving direct abundances, modeling their ionization and thermal structures, and study their massive stellar content. Out of this sample we have selected 10 HII regions located in five galaxies and that are believed, based on direct methods, to have oxygen abundances betweeen 0.7 and 1.7 times the solar value. We are proposing to obtain Spitzer IRS Short-High spectra for these 10 giant HII regions in order to measure the following emission lines: [Ne II] 12.8, [Ne III] 15.6, [S III] 18.7 and [S IV] 10.5. These fine-structure lines provide sensitive probes of metal abundances. Forming ratios between these lines and the available optical lines offers powerful diagnostics of the hardness of the stellar ionizing field and of the nebular temperature. By fully exploiting the combination of optical and infrared spectra it will be possible to verify the presence of severe abundance biases at high metallicity, as predicted for metal-rich HII regions by 'ab initio' models, and eventually to obtain significantly improved determinations of chemical abundances in giant HII regions, and in star-forming galaxies in the Universe in general.

Spitzer Space Telescope - General Observer Proposal #40002

The Structure and Evolution of Stellar Wind-Blown Dust Bubbles

Principal Investigator: Edward Churchwell
Institution: University of Wisconsin, Madison

Technical Contact: Edward Churchwell, University of Wisconsin, Madison

Co-Investigators:
Mark Wolfire, University of Maryland
Christer Watson, Manchester College
Barbara Whitney, Space Science Institute

Science Category: HII regions
Observing Modes: IrsMap
Hours Approved: 19.5

Abstract:
We propose to obtain partial spectral line images, using Spitzer/IRS, of four carefully selected Galactic infrared bubbles (detected in the GLIMPSE survey) that have different morphologies and are believed to represent different stages of evolution. The main goals of this program are to: test and constrain dynamical evolution models of bubbles produced by young O-stars. Temperature, density, and velocity structure are predicted to change by orders of magnitude with age and with radius from the central star(s). Confirmation of these predictions has had limited success because of limitations imposed by extinction, sensitivity, spatial resolution, and access to probes that sample a wide range of ionization. IRS is ideally suited to detect and measure the radii of the various ionization zones and transition regions within stellar wind-blown bubbles. We propose to do this by obtaining spectral line images of a strip across the diameter of the four selected bubbles.

Spitzer Space Telescope - General Observer Proposal #50598

IRS Spectral Maps of Photoevaporative Columns in M16, Carina, and the Galactic Center

Principal Investigator: Angela Cotera
Institution: SETI

Technical Contact: Angela Cotera, SETI

Co-Investigators:
Susan Stolovy, Spitzer Science Center
Janet Simpson, NASA Ames Research Center
Kris Sellgren, University of Ohio
Jeff Hester, Arizona State University
Kevin Healy, Arizona State University

Science Category: HII regions
Observing Modes: IrsMap
Hours Approved: 22.8

Abstract:
Photoevaporated columns of dust and gas - also called elephant trunks, pillars or fingers - are found in the periphery of H II regions, and have been observed within the Galaxy, the SMC and the LMC. These features are sites of current star formation, but the question remains whether the columns persist because stars formed in the denser regions prior to interactions with the UV radiation and stellar winds of nearby massive stars, or because of core collapse resulting from these interactions. Mapping the distribution of the physical states of the dust and gas in these columns is a necessary step towards understanding the possible star formation mechanisms within these dynamic objects. We propose to obtain IRS spectral maps of columns within M 16, the Carina nebula, and the Galactic center (GC) to understand the effects on these pillars from different stellar populations and initial conditions, and to better understand star formation in the GC. Within the spectral range of the high resolution IRS modes (9.9-37.2 micron) there are a wealth of molecular, atomic and PAH emission lines that will enable us to determine the excitation state, dust and gas temperatures, and probe the shock characteristics within the columns. Using the IRS spectral mapping mode, in conjunction with the CUBISM tool and the CLOUDY H II region model code, we will be able to construct detailed maps of the accessible emission lines and derived parameters for each column. IRS mapping of elephant trunks has not been done to date, yet provides a wealth of information unobtainable for the foreseeable future once Cycle 5 is completed.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #218

Trifid Nebula

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: William Reach, Caltech

Science Category: HII regions
Observing Modes: IracMap MipsPhot
Hours Approved: 2.9

Abstract:
The Trifid Nebula (M20) is a double-nebula, with a blue reflection nebula above a red ionized nebula, the latter being trisected by dark lanes. This observing program iamges the reflection and ionized nebulae and the dark lanes. The mid-infrared emission will trace the reflection nebula via aromatic hydrocarbon emissions and the dark lane via hot, small grains. Massive protostars have been detected in the dark lanes using submillimeter observations; the new mid-infrared observations will fully sample the lower-mass protostars. The Trifid is one of the youngest known HII regions, and the interaciton of its young, massive O-type star with its surrounding placental material is clearly affecting its ability to form new stars.

Spitzer Space Telescope - Theoretical Research Proposal #20269

Jets, Outflows and Feedback in Young Clusters

Principal Investigator: Adam Frank
Institution: University of Rochester

Technical Contact: Adam Frank, University of Rochester

Co-Investigators:
Alice Quillen, University of Rochester

Science Category: HII regions
Dollars Approved: 70000.0

Abstract:
Energetic outflows associated with young stellar objects exert a strong effect on their parent molecular clouds. Currently the role of jets and outflows in opening cavities, generating turbulence and/or disrupting their parent clouds remains unclear. Spitzer images of young clusters provide new views of jet cloud interactions that can help resolve these critical issues. We propose to use 3-D Adaptive Mesh Refinement hydrodynamic and magnetohydrodynamic simulations, in concert with Spitzer databases and other complementary observations, to explore the issue of jet cloud interactions, turbulence and cloud disruption. By modeling the jet/cloud interactions with a firm connection to the propoerties of the observed YSOs and molecular cloud dynamics, we will probe the nature of momentum input into molecular clouds and use the motions in the molecular cloud to trace the evolution of outflow and winds from YSOs.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #18

H2 column densities and relative HD abundances toward a variety of warm regions in the Galaxy and the LMC/SMC

Principal Investigator: James R. Houck
Institution: Cornell University

Technical Contact: Keven Uchida, Cornell University

Science Category: HII regions
Observing Modes: IrsMap IrsStare
Hours Approved: 3.5

Abstract:
The relative deuterium abundance in the galaxy, and ultimately, the cosmological deuterium abundance, can be determined only if reliable H2 reference column densities can be derived. A promising way to derive H2 column densities is via the mid-IR rotational lines of para-H2 (S(2) 12 micron and S(0) 28 micron) and ortho-H2 (S(1) 17 micron). We use the IRS to observe these lines toward a number of Galactic HII and SNR regions (M17SW, IC443 and NGC1096A) and regions in the LMC and SMC (N44, N81, N83B, N88, N113, N159A, N160A, LIRS36). Corresponding observations of the HD(1-0) line at 112 microns will be performed with SOFIA. One of us (R.Guesten) is PI of the 2.6 THz heterodyne instrument dedicated to observations of this transition aboard SOFIA.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #63

Comparative Study of Galactic and Extragalactic HII Regions

Principal Investigator: James R. Houck
Institution: Cornell University

Technical Contact: Bernhard Brandl, Sterrewacht Leiden

Science Category: HII regions
Observing Modes: IracMap IrsMap IrsStare MipsPhot
Hours Approved: 35.0

Abstract:
The objective of our program is to study the interplay between massive stars and the ISM in HII regions. Our sample of Galactic and Extragalactic HII regions spans a wide range in metallicity, density, mass and age. We will use the IRS to determine the general properties of the regions using line ratios, the strength of the PAH features, and the H2 column density at numerous locations within the clusters. In addition we will use IRAC and MIPS for mapping of the PAH features (IRAC) over a larger field and the detection of massive, embedded stellar sources (MIPS).

Spitzer Space Telescope - General Observer Proposal #20281

Very Small Particles in Photodissociation Regions : further insights with MIPS SED

Principal Investigator: Christine Joblin
Institution: Centre d'Etude Spatiale des Rayonnements; CNRS-UPS

Technical Contact: Laurent Verstraete, IAS

Co-Investigators:
Alain Abergel, IAS
Jean-Philippe Bernard, CESR
Francois Boulanger, IAS
Jose Cernicharo, IEM-CSIC
Yannick Deville, LATT-OMP
Maryvonne Gerin, LERMA-OPM
Javier Goicoechea, LERMA-OPM
Emilie Habart, Oss. Astr. Arcetri
Jacques Le Bourlot, LUTH-OPM
Jean-Pierre Maillard, IAP
William Reach, IPAC
Aude Simon, CESR
John-David Smith, Steward Obs.
David Teyssier, SRON
Laurent Verstraete, IAS

Science Category: HII regions
Observing Modes: MipsSed
Hours Approved: 8.5

Abstract:
The goal of this proposal is to complement our successful Spitzer cycle 1 program ''SPECPDR'' dedicated to the study (with IRS, IRAC and MIPS) of the nature and evolution of very small dust particles (very small grains and PAHs) and the chemistry in PDRs. Now available for the first time, the MIPS-SED mode is well suited to study the emission of the big grains in thermal equilibrium with the radiation field in PDRs. Combining the spectro-imagery IRS and MIPS-SED observations, it will be possible to follow the spatial evolution of the abundance and size distribution of the different dust populations. Moreover, the combination of the important gas cooling line of [OI] at 63 micron with the dust emission will allow us to constrain the photoelectric efficiency. It will also probe the impact on the gas thermal balance of abundance variations of the very small dust particles. These data will be a benchmark for models describing the nature and evolution of all dust populations as well as for the excitation and formation of H2.

Spitzer Space Telescope - General Observer Proposal #3512

Very Small Particles and Chemistry in Photodissociation Regions

Principal Investigator: Christine Joblin
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Technical Contact: Laurent Verstraete, Inst. d'Astrophysique Spatiale

Co-Investigators:
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William Reach, IPAC, CA-USA
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David Teyssier, SRON, Netherlands
Keven Uchida, Cornell Univ
Laurent Verstraete, IAP, France

Science Category: HII regions
Observing Modes: IracMap IrsMap MipsPhot
Hours Approved: 26.4

Abstract:
The very small particles play a major role in the physics and chemistry of the interstellar medium, since they dominate the heating of interstellar gas through photoelectric effect and contribute to the formation of H2. Excited by single UV photons, their emission can be disentangled from other dust components only in faint regions with low excitation and with a high spatial resolution. We propose to use the unique spectro-imagery capabilities of the Spitzer Space Telescope to study the nature and the evolution of the very small particles together with the chemistry (H2 formation) across low excitation PDRs. Our sources are selected in order to span a broad range of physical conditions (radiation field, geometry and density). Low and high spectral resolution observations are conducted at positions precisely selected from ISO observations. Broad-band mapping in the four bands of IRACand MIPS at 24 microns complement the spectroscopic observations. The data will be interpreted in the frame of a PDR and a dust models, and the results tested with a laboratory set-up allowing to simulate the interstellar conditions. Finally our studies of local PDR will be very helpful to interpret data in external galaxies taken by other Spitzer programs.

Spitzer Space Telescope - Archive Research Proposal #30696

A Comparison of the Infrared and Ultraviolet Properties of Photodissociation Regions

Principal Investigator: Stephan McCandliss
Institution: Johns Hopkins University

Technical Contact: Stephan McCandliss, Johns Hopkins University

Co-Investigators:
Kevin France, Johns Hopkins University
Roxana E. Lupu, Johns Hopkins University

Science Category: HII regions
Dollars Approved: 65680.0

Abstract:
We propose to compare Spitzer observations of molecular hydrogen, PAHs, and thermal dust emission with recent studies of molecular hydrogen and interstellar dust at ultraviolet wavelengths. We will use archival observations of six photodissociation regions to examine the environmental dependences of PAH emission. This will be accomplished by looking for correlations between PAHs and fluorescent molecular hydrogen, relative to the strength of the ultraviolet radiation field and the nebular geometry. This investigation would provide a multi-wavelength observational base for future studies of molecular hydrogen and dust grains in PDRs.

Spitzer Space Telescope - General Observer Proposal #20517

Very Small Grains and the mid-IR continuum emission from (ultra)compact HII regions

Principal Investigator: Els Peeters
Institution: NASA Ames Research Center

Technical Contact: Els Peeters, SETI Institute

Co-Investigators:
L.J. Allamandola, NASA Ames Research Center
A.G.G.M. Tielens, Kapteyn Instituut, Groningen, The Netherlands

Science Category: HII regions
Observing Modes: IrsMap
Hours Approved: 4.2

Abstract:
Over the last decade, much effort has been expended on characterizing and understanding the well-known mid-IR emission features at 3.3, 6.2, 7.7, and 11.2 um, generally attributed to Polycyclic Aromatic Hydrocarbon molecules. However, the spectra of many sources also show a weak underlying mid-IR continuum. The origin of this continuum, which varies independently from these IR features, is less clear but, is often attributed to emission by very small dust particles (VSGs, ~20 A). These VSGs are a very important component of the interstellar dust. However, the weakness of the mid-IR continuum and the limited sensitivity of IR detectors has up to now seriously hampered detailed observational investigations of the carriers of this continuum. Hence, the characteristics of these VSGs are presently ill-constrained. We propose to use the ultimate sensitivity of the IRS on Spitzer to study the mid-IR continuum emission in a sample of (ultra)-compact HII regions which span a wide range in the strength of the FUV field and density. The proposed observations will provide a direct handle on the abundance and the heating agent of their carriers and their interrelationship to the IR emission features.

Spitzer Space Telescope - General Observer Proposal #50713

The 15-20 um PAH emission

Principal Investigator: Els Peeters
Institution: SETI Institute

Technical Contact: Els Peeters, SETI Institute

Co-Investigators:
Alexander Tielens, NASA Ames Research Center
Louis Allamandola, NASA Ames Research Center

Science Category: HII regions
Observing Modes: IrsMap
Hours Approved: 4.3

Abstract:
Spitzer has discovered emission features between 15 - 20 um that are considered new members of the PAH emission band family. These observations clearly indicate that this emission is comprised of at least two classes of independent components: distinct, narrow features and broad variable plateaus. These two components seem to be related with object type. Within the extended star forming region Orion both the broad plateau and the complex of narrow features are observed, suggesting that either the carrier of the broad plateau is more stable against UV photons than the carrier of the distinct narrow features (e.g. larger size) or the ionization state of the carrier of both features is different. In other objects, such as NGC2023, the relative intensities of the narrow features seem to vary with distance from the exciting star. Here, we propose to obtain SH spectral maps of 3 well-studied HII regions to investigate variations and similarities in the 15-20 um PAH emission as a function of position across the HII region and immediate surroundings. These data will be compared to our previous data of the distribution of the shorter wavelength main PAH features, the continuum dust emission and the emission of the ionized gas. The 15 to 20 um features will be analyzed using the Ames PAH IR spectral database, permitting characterization of the long wavelength PAH features. Combined, these results will paint a more detailed picture of characteristics of the carrier of the long wavelength PAH emission.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40359

IRAC/MIPS Survey of the Rosette Nebula

Principal Investigator: George Rieke
Institution: University of Arizona

Technical Contact: Zoltan Balog, University of Arizona

Co-Investigators:
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Carlos Roman-Zuniga, Harvard-Smithsonian CfA
Nadya Gorlova, University of Florida
Gabor Furesz, Smithsonian Astrophysical Observatory

Science Category: HII regions
Observing Modes: IracMap MipsPhot MipsScan
Hours Approved: 10.7

Abstract:
The Rosette Nebula, which is one of the nearest high-mass star forming regions, is probably the best place to study the effect of high mass stars on their local environment. This program proposes to map the western part of the nebula as well as three smaller non-associated parts with IRAC and MIPS. These regions were missed by the previous IRAC and MIPS surveys. With the new observations we cover virtually the entire nebula and also match the deep near-IR FLAMINGOS survey of the region. Combination of the near to mid IR photometric data and high resolution spectroscopy of young stars embedded in the nebula will help us answer fundamental questions regarding the star formation history and the propagation of star formation in the cloud. By comparing our results with those for less violent star forming regions, we will be able to study the effect of high mass stars on the surrounding star formation environment

Spitzer Space Telescope - General Observer Proposal #50082

What's behind Orion's Bar?

Principal Investigator: Robert Rubin
Institution: NASA Ames Research Center

Technical Contact: Robert Rubin, NASA Ames Research Center

Co-Investigators:
C. Robert O'Dell, Vanderbilt University
Gary Ferland, University of Kentucky
Sean Colgan, NASA Ames Research Center
Janet Simpson, SETI Institute
Edwin Erickson, NASA Ames Research Center

Science Category: HII regions
Observing Modes: IrsMap
Hours Approved: 24.8

Abstract:
We propose to obtain deep spectra of the outer region of the Orion Nebula. The area of particular interest is SE of the Bar where archival Spitzer spectra have shown high signal-to-noise lines of [S IV] 10.5 and [Ne III] 15.6 microns. We were staggered with astonishment to see such S/N in high ionization species well beyond the Bright Bar, given the conventional view of the Bar as the boundary between ionized and photodissociated regions (PDR). Previous IR missions observed only the inner few arcmin, the so-called Huygens region. The extreme sensitivity of Spitzer's IRS short-high (SH) and long-high (LH) modules in the 10-37 micron spectral range will permit us to measure the above lines and many others of interest to much larger distances from the exciting star theta1 Ori C. Orion is the benchmark for studies of the interstellar medium, particularly for elemental abundances. In the case of the Orion Nebula, the best way to obtain abundances from observations has been through detailed photoionization modeling. These new Spitzer spectra will provide a unique, legacy dataset for new science, including improved current and future models of Orion. Indeed we will use our own modeling codes for this purpose, one of which self-consistently treats the H II region and the PDR. The Orion Bar is the defining interface by which all H+ - H0 - H2 regions are judged. Because there must be extra emission along this sight line, we need to understand this contribution and remove what is not physically a part of the Bar. Our program will permit a more reliable set of line emission that actually arises from the Bar that can rigorously be used to define the interface problem. Our spectra will be the deepest ever taken in these outer regions of Orion over the 10-37 micron range. Tracking the changes in ionization structure via the line emission to larger distances provides much more leverage for understanding the far less studied outer regions. The outer Veil is likely to provide a new, benchmark HIIR-PDR interface.

Spitzer Space Telescope - General Observer Proposal #3420

Spitzer Survey of Triggered Star Formation in the Carina Nebula

Principal Investigator: Nathan Smith
Institution: University of Colorado

Technical Contact: Nathan Smith, University of Colorado

Co-Investigators:
John Bally, University of Colorado
Ed Churchwell, University of Wisconsin
Robert Gehrz, University of Minnesota
Jon Morse, Arizona State University
Keivan Stassun, Vanderbilt University

Science Category: HII regions
Observing Modes: IracMap
Hours Approved: 9.1

Abstract:
The Carina Nebula is arguably the best available laboratory for studying active star formation threatened by feedback from extremely massive stars, including several of the most luminous O-type stars known, WR stars, and Eta Carinae. It is close enough that we can study the low-mass stellar population, we can detect protoplanetary disks and jets, and we can spatially resolve individual stars, star-forming cores, and ultracompact HII regions. Thus, we can identify the dominant physical processes at work to gain insight to the detailed processes occurring in extragalactic starbursts. The main long-term goal is to determine if detailed models derived from study of Orion and Taurus can be applied in more extreme regions like Carina, or in what ways they need to be modified. We propose roughly 9 hours of Spitzer time using IRAC to survey 1.2 square degrees of the southern part of the Carina Nebula. This region is a vivid example of second-generation (possibly triggered) star formation, containing dozens of compact IR sources and giant dust pillars that point toward Eta Carinae. A large IR survey like this is not feasible with ground- based instrumentation, and the relatively low spatial resolution of MSX or IRAS is of limited usefulness in such a complex region. Our proposed survey will be fully-sampled and confusion limited in the IRAC bands, and will provide an excellent compliment to the GLIMPSE legacy program, which does not include the Carina Nebula.

Spitzer Space Telescope - General Observer Proposal #20097

Tracking Warm H2 in Photodissociation Regions

Principal Investigator: Mark Wolfire
Institution: University of Maryland

Technical Contact: Mark Wolfire, University of Maryland

Co-Investigators:
David Hollenbach, NASA/Ames Research Center
Michael Kaufman, San Jose State University

Science Category: HII regions
Observing Modes: IrsMap
Hours Approved: 23.8

Abstract:
Photodissociation regions (PDRS) include all regions of the interstellar medium in which far-ultraviolet photons play an important role in the chemistry or heating of the gas. These include HI clouds, the surfaces of molecular clouds illuminated by the interstellar radiation field, and molecular clouds illuminated by intense radiation from nearby massive stars. In general, models provide a good match to the observations, but several recent observations of H_2 and CO indicate that models underestimate the gas temperature. We propose to conduct IRS mapping observations of the warm H_2 in several PDRs. The high spatial resolution and sensitivity of Spitzer will allow us to test PDR models and determine if additional sources of heating are required. In addition we will determine the extent and source of the [Si II] and [Fe II] fine-structure lines. These diagnostic lines are especially important for extragalactic observations where beams typically include both neutral and ionized gas. It is essential to understand the thermal processes in PDRs in order to use PDR models in comparison with data, to derive physical parameters in the ISM of our Galaxy, as well as external galaxies.

Spitzer Space Telescope - General Observer Proposal #3697

Tracking Warm H_2 in Photodissociation Regions

Principal Investigator: Mark Wolfire
Institution: University of Maryland

Technical Contact: Mark Wolfire, University of Maryland

Co-Investigators:
Michael Kaufman, San Jose State University
David Hollenbach, NASA Ames Research Center

Science Category: HII regions
Observing Modes: IrsMap
Hours Approved: 7.8

Abstract:
Photodissociation regions (PDRS) include all regions of the interstellar medium in which far-ultraviolet photons play an important role in the chemistry or heating of the gas. These include HI clouds, the surfaces of molecular clouds illuminated by the interstellar radiation field, and molecular clouds illuminated by intense radiation from nearby massive stars. In general, models provide a good match to the observations, but several recent observations of H_2 and CO indicate that models underestimate the gas temperature. We propose to conduct IRS mapping observations of the warm H_2 in the M17-SW PDR. The high spatial resolution and sensitivity of Spitzer will allow us to test PDR models and determine if additional sources of heating are required. In addition we will determine the extent and source of the [Si II] and [Fe II] fine-structure lines. These diagnostic lines are especially important for extragalactic observations where beams typically include both neutral and ionized gas. It is essential to understand the thermal processes in PDRs in order to use PDR models in comparison with data, to derive physical parameters in the ISM of our Galaxy, as well as external galaxies.

Spitzer Space Telescope - Theoretical Research Proposal #30316

Theoretical Studies to Support Spitzer Cluster Surveys

Principal Investigator: Fred Adams
Institution: University of Michigan

Technical Contact: Fred Adams, University of Michigan

Co-Investigators:
Lori Allen, Center for Astrophysics
Tom Megeath, Center for Astrophysics/Univ. Toledo
Phil Myers, Center for Astrophysics

Science Category: star formation
Dollars Approved: 58768.0

Abstract:
For young clusters in the regime of parameter space found in the Spitzer sample, this project will conduct a theoretical study of their dynamical evolution, starting from their earliest embedded stage (when the first star forms) out to ages of 10 Myr. The latest Spitzer observations will be used to set the initial profiles of the cluster systems to be explored. We will then use N-body simulations for cluster systems (generally with N = 100 - 1000 members) to study how their evolution depends on cluster size, initial stellar and gas profiles, initial mass segregation, and the gas dispersal history. The project will be statistical in nature, utilizing multiple equivalent realizations to build up robust distributions of the output measures, including distributions for the closest approaches of cluster members, distributions of radial locations (which largely determine the radiation exposure), the bound cluster fraction, the virial ratio, the isotropy parameter, and the half-mass radius. We anticipate that about 100 realizations for each set of initial conditions must be performed in order to obtain robust statistics. We will also produce distributions of the radiation fluxes produced by the cluster sample, with a focus on FUV, EUV, and X-ray radiation. The resulting output distributions will provide a lasting framework from which to assess the effects of clusters on the star formation process. The distributions of closest approaches will be used in conjunction with scattering cross sections to determine the importance of dynamical interactions on forming solar systems. The distributions of radiation fields will be used in conjunction with theoretical models to determine the importance of disk photoevaporation. Most stars, and most planets, form in clusters, and this work will elucidate the role played by the cluster environment in shaping the properties of the constituent solar systems.

Spitzer Space Telescope - Legacy General Observer Proposal #30574

Gould's Belt: Star Formation in the Solar Neighborhood

Principal Investigator: Lori Allen
Institution: Smithsonian Astrophysical Observatory

Technical Contact: Lori Allen, Smithsonian Astrophysical Observatory

Co-Investigators:
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Jes Jorgensen, CfA
James Di Francesco, NRC-HIA
Neal Evans, Univ. Texas
Tim Brooke, Caltech
Paul Harvey, Univ. Texas
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Tyler Bourke, CfA
Jane Greaves, St. Andrews
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Jason Kirk, Cardiff University
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Bruno Merin, Leiden
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Philip Myers, CfA
Deborah Padgett, Spitzer Science Center
Luisa Rebull, Spitzer Science Center
Karl Stapelfeldt, JPL
Derek Ward-Thompson, Cardiff University
Jeremy Yates, Univ. College London

Science Category: star formation
Observing Modes: IracMap MipsScan
Hours Approved: 285.0

Abstract:
We propose a Legacy program to obtain observations with IRAC and MIPS of molecular clouds in Gould's Belt. These will provide the crucial data shortward of 200 microns to match the data from large projects with SCUBA-2 on the JCMT (450 and 850 microns) and SPIRE (200 to 500 microns) on Herschel. Together with the clouds surveyed by the Cores to Disks (c2d) Spitzer Legacy program and clouds studied by GTO/GO programs, these observations will complete the census of star formation regions within 500 pc. All Spitzer data, including previous GTO/GO data, will be processed through the c2d pipeline to produce a uniform, complete, and unbiased data base for studies of local star formation. Scientific goals include the following. We will determine which of the many dense cores detected by SCUBA-2 have embedded stars and which are starless. We will compile the statistics of objects in different evolutionary stages to obtain timescales for these stages, a fundamental check on theory. We will use the large sample to control for effects of enviroment on star formation. We will assess the fraction of star formation in distributed and clustered modes, including the number in groups of various sizes. Finally, we will combine the MIPS data with the submillimeter data to study the physical conditions in extended structures with a goal of understanding the formation of dense cores.

Spitzer Space Telescope - General Observer Proposal #30760

Gas Entrainment and Shock Physics in Giant Protostellar Outflows

Principal Investigator: Hector Arce
Institution: American Museum of Natural History

Technical Contact: Hector Arce, American Museum of Natural History

Co-Investigators:
Alberto Noriega-Crespo, Spitzer Science Center
Mordecai-Mark Mac Low, American Museum of Natural History
Alex Rosen, Max Planck Institute for Radioastronomy
Alyssa Goodman, Harvard University
Alex Raga, UNAM

Science Category: star formation
Observing Modes: IracMap IrsMap IrsStare
Hours Approved: 20.4

Abstract:
The colossal size of giant Herbig-Haro (HH) flows enable them to impact cloud material parsecs away from their source, thereby affecting the kinematics, density and chemistry of a substantial volume of their parent cloud. These energetic phenomena are very important to the general dynamics and evolution of star-forming regions. We propose to observe two giant outflows with IRAC and IRS. Using deep IRAC images, we will map the total extent of the giant outflow cavities. The IRAC data will be used to analyze the morphology, luminosity and shape of the flows, which will then be compared to high-resolution molecular outflow (CO) maps in order to study the outflow entrainment process. We will also compare our data with hydrodynamic simulations of outflows in order to further constrain the nature of the protostellar wind and the outflow-cloud interactions. IRS maps will provide the data to study the properties of the shocks responsible for entraining the surrounding gas. Combining the IRS data and multi-line millimeter data will allow us to estimate the energy transfer efficiency between shocks and the cloud gas and will provide observational constrains to shock chemistry models.

Spitzer Space Telescope - General Observer Proposal #30896

A Multi-Epoch IRS Accretion Variability Study of Actively Accreting T Tauri Stars

Principal Investigator: Jeffrey Bary
Institution: University of Virginia

Technical Contact: Jeffrey Bary, University of Virginia

Co-Investigators:
Michael Skrutskie, University of Virginia
Dawn Peterson, University of Virginia

Science Category: star formation
Observing Modes: IrsStare
Hours Approved: 7.7

Abstract:
We propose to use Spitzer and IRS in SL1 and SL2 modes to continue a short-/long-term survey of actively accreting T Tauri stars. These observations will be combined with observations taken during and currently scheduled in Cycle 2 and coordinated with an on-going near-infrared spectroscopic survey of the same sources. We hope to characterize the time dependence and nature of accretion variability in these sources and determine if a correlation exists between inner and outer disk accretion activity. We expect the accretion variability to manifest itself as fluctuations in the shapes of the near-IR and mid-IR spectral energy distributions as well as variataions in the line strength and shapes of accretion-related emission line features.

Spitzer Space Telescope - Legacy General Observer Proposal #30570

GLIMPSE 3D: The Vertical Stellar and Interstellar Structure of the Inner Galaxy

Principal Investigator: Robert Benjamin
Institution: University of Wisconsin-Whitewater

Technical Contact: Robert Benjamin, University of Wisconsin-Whitewater

Co-Investigators:
Ed Churchwell, University of Wisconsin-Madison
Marilyn Meade, University of Wisconsin-Madison
Brian Babler, University of Wisconsin-Madison
Barbara Whitney, Space Science Institute
Michael Merrifield, University of Nottingham
Martin Cohen, University of California-Berkeley
Christer Watson, Manchester College
Joris Blommaert, Instituut voor Sterrenkunde, K.U. Leuven

Science Category: star formation
Observing Modes: IracMap
Hours Approved: 254.5

Abstract:
Galaxies are three-dimensional stellar systems, but for external galaxies, we are limited to studying a two dimensional projection. There is only one system where we can obtain a three dimensional view: our own Milky Way. Fundamental questions of vertical Galactic stellar structure can be most profitably pursued in investigations of our own Galaxy, but studies of stellar distributions with 2MASS and other near IR surveys in the inner Galaxy have been fundamentally limited by extinction. Investigations with COBE/DIRBE have shown that the mid-infrared is the optimum wavelength range for studies of Galactic stellar structure; early results using data from the GLIMPSE confirm this. However, GLIMPSE data is insufficient to constrain the vertical scaleheights of the different components of the Galaxy. We propose to use IRAC for 254.5 hours to map 112 square degrees in a series of latitude strips above and below the Galactic plane in all four IRAC bands. These latitude strips will stretch up to abs(b)<4.2 deg around the central region of the Galaxy (abs(l)<2 deg) and include Baade's window. They will cover abs(b)<3 deg for six latitude strips centered at l=3.5, 11, 15, 18.5, 25,and 30 deg. The resulting dataset can be used to determine the scaleheight of the Galactic bulge, the Galactic bar(s), the thin stellar disk, the Galactic ring, and the inner spiral arms, with a variety of different stellar tracers. Mosaicked images will be supplied to community, and a point source Catalog and Archive will be produced and merged with the 2MASS catalog, allowing the study of SEDs from 1-8 microns for all sources. This project will also enable many other scientific investigations, including off-plane star formation, studies of diffuse IR cirrus, and the vertical scaleheights of different stellar populations. The understanding of Milky Way stellar structure gained from this project will be an important legacy for Galactic and extragalactic researchers alike.

Spitzer Space Telescope - Archive Research Proposal #40592

Peering into the Heart of Galactic Star Formation

Principal Investigator: Edwin Bergin
Institution: University of Michigan

Technical Contact: Sarah Ragan, University of Michigan

Co-Investigators:
Sarah Ragan, University of Michigan

Science Category: star formation
Dollars Approved: 70221.0

Abstract:
Key to the advancement of a star formation study is the identification and characterization of the earliest stages of the process. Infrared dark clouds are excellent candidates for the precursors to massive stars and stellar clusters. Furthermore, the location of many IRDCs is in the Galactic Molecular Ring, where the majority of stars are born in our Galaxy. Given the larger distances, the similarity between the process of star formation in the Ring and in the local clouds is relatively unexplored. We have developed a technique for isolating fragmenting clumps with IRDCs and determining their properties in an automated manner based on absorbing structures evident in IRAC 8-micron and MIPS 24-micron images. We propose here to exploit the wealth of data in the GLIMPSE and MIPSGAL archives to compile a sample of thousands of clumps with the following scientific goals: determine the clump mass function, isolate the pre-stellar phase of massive stars, examine the clump mass-size relation, and evaluate the level of mass segregation. The proposed study offers the opportunity to characterize and contrast star formation in a new environment as has been done for local clouds.

Spitzer Space Telescope - General Observer Proposal #30919

IRS spectroscopy of extremely young massive protostars

Principal Investigator: Stephan Birkmann
Institution: Max-Planck-Institute for Astronomie

Technical Contact: Stephan Birkmann, Max-Planck-Institute for Astronomie

Co-Investigators:
Martin Hennemann, Max-Planck-Institute for Astronomy
Juergen Steinacker, Max-Planck-Institute for Astronomy
Dietrich Lemke, Max-Planck-Institute for Astronomy

Science Category: star formation
Observing Modes: IrsStare
Hours Approved: 5.0

Abstract:
We have established a sample of massive pre-stellar core candidates using the ISOPHOT Serendipity Survey (ISOSS) and ground based follow-up observations in the (sub)mm continuum and of molecular lines. Thirteen of these sources were successfully observed with IRAC and MIPS during GO Cycle 2. Despite their early evolutionary stage, indicated by low dust and gas kinetic temperatures, all objects have embedded point sources detected with MIPS at 24 um. The origin of this mid-infrared emission is yet unknown but might be due to the potential energy released during the initial gravitational collapse of the core, becoming a massive protostar or protocluster. We have therefore selected a subsample of six objects for follow-up observations with IRS and ask for 5 hours of Spitzer time. The IRS spectra are mandatory to characterize the physical conditions in the discovered mid-infrared sources and unveil their true nature. This will be achieved by means of radiative transfer modeling and warm gas diagnostics.

Spitzer Space Telescope - General Observer Proposal #40569

Completing the IRS spectroscopy of young massive protostars

Principal Investigator: Stephan Birkmann
Institution: Max-Planck-Institut fuer Astronomie

Technical Contact: Martin Hennemann, Max-Planck-Institut fuer Astronomie

Co-Investigators:
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Dietrich Lemke, Max-Planck-Institut fuer Astronomie

Science Category: star formation
Observing Modes: IrsStare
Hours Approved: 2.2

Abstract:
This proposal is a partial resubmission of the Cycle-3 program 30919, PI S. Birkmann. Two targets of that program were not observed because of an error during peak-up acquisition. Our initial sample consists of 13 massive pre-stellar core candidates established using the ISOPHOT Serendipity Survey (ISOSS) and submm and molecular line observations. These were successfully observed with IRAC and MIPS during GO Cycle-2, and despite their early evolutionary stage indicated by low dust and gas kinetic temperatures all of them show embedded 24 um sources that may correspond to extremely young protostellar objects. To be able to characterize the physical conditions in the discovered MIR sources we selected a subsample of six objects for follow-up IRS observations in Cycle-3 which are partly accomplished. Based on the Spitzer photometric data they are believed to represent different evolutionary stages, and the two sources not observed constitute the most extreme cases. Via radiative transfer modeling and warm gas diagnostics we aim to identify the nature of the discovered sources and place them in an evolutionary context. To achieve this, it is mandatory to include the missing sources and therefore we propose to carry out the observations towards them.

Spitzer Space Telescope - General Observer Proposal #30384

Going Long: Studying the Initial Conditions for Brown Dwarfs and Low-Mass Stars with Spitzer at 160 microns

Principal Investigator: Tyler Bourke
Institution: Harvard-Smithsonian Center for Astrophysics

Technical Contact: Tyler Bourke, Harvard-CfA

Co-Investigators:
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Neal Evans II, University of Texas at Austin
Michael Dunham, University of Texas at Austin
Deborah Padgett, Spitzer Science Center
Jes Jorgensen, Harvard-Smithsonian Center for Astrophysics
Yancy Shirley, Steward Observatory
Tracy Huard, Harvard-Smithsonian Center for Astrophysics
Tim Brooke, Caltech
Jens Kauffmann, Max-Planck-Institut fur Radioastronomie

Science Category: star formation
Observing Modes: MipsScan
Hours Approved: 47.3

Abstract:
We propose to obtain 160 micron maps of 13 dense cores with faint embedded sources (VeLLOs) and of 27 cores which lack sources. These cores were already mapped by Spitzer at shorter wavelengths, and by ground based telescopes at longer wavelengths. They have no observations near 160 microns, so their peak flux and total luminosities are very uncertain, as are the effects of the ISRF on their temperature stucture. Our proposed observations will determine each spectrum and its luminosity accurately enough to separate the contributions from internal and external heating. With current data, several of the embedded sources have luminosity < 0.1 Lsun, among the lowest known, which indicates substellar masses according to simple accretion models. Our more accurate luminosities will be used to estimate whether these sources have masses of brown dwarfs or of stars, and the related question of whether these sources have mass accretion rates expected from the standard model of low-mass star formation.

Spitzer Space Telescope - General Observer Proposal #50477

Lonely Cores: Star Formation in Isolation

Principal Investigator: Tyler Bourke
Institution: Harvard-Smithsonian Center for Astrophysics

Technical Contact: Tyler Bourke, Harvard-SAO

Co-Investigators:
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Tracy Huard, Maryland
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Jens Kauffmann, SAO
Jason Kirk, Univ. Cardiff
Jeong-Eun Lee, Korea
Philip Myers, SAO
Dawn Peterson, SAO
Amelia Stutz, Univ. Arizona
Derek Ward-Thompson, Univ. Cardiff

Science Category: star formation
Observing Modes: IracMap MipsScan
Hours Approved: 72.6

Abstract:
The standard model of low mass star formation was developed and has evolved through detailed studies of relatively isolated cores and protostars. They are still the best places in which to study the star formation process in detail, as they are nearby and free of the confusing effects of star formation in large molecular clouds and clusters. Many details are still unclear however, and studies of a large ensemble of cores at different evolutionary stages in different environments are needed to address the following outstanding questions: (1) What are the relative numbers of cores at the different evolutionary stages, and so what are their lifetimes? (2) How does the physical structure of a core evolve? (3) How does the evolution of cores to protostars and the efficiency of star formation depend on environment? (4) When do cores form protostars? (5) How do core luminosities and spectral energy distributions (SEDs) change as a function of evolutionary state? All of these issues arise from the key question in star formation: how do dense cores evolve to form stars? These questions can be directly addressed by a combination of existing and new Spitzer observations. Spitzer has observed a number of nearby dense relatively isolated cores as part of c2d and GTO programs. The existing data however do not allow for is a systematic study of the entire star formation process, as it is biased against the youngest, low density cores, and completely isolated cores, and so does not probe the earliest stages of star formation, nor the effects of environment. We propose to double the sample of isolated low-mass cores observed with Spitzer with the additional sample selected in such a way as to remove these biases. We will determine their structure through extinction mapping with IRAC (combined with K-band observations), and their protostellar content or lack thereof with sensitive MIPS observations. Our proposed observations will provide much needed insight into the low-mass star formation process.

Spitzer Space Telescope - General Observer Proposal #50326

Direct Physical Diagnostics of Triggered Star Formation

Principal Investigator: Crystal Brogan
Institution: National Radio Astronomy Observatory (NRAO)

Technical Contact: Crystal Brogan, NRAO

Co-Investigators:
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Claudia Cyganowski, University of Wisconsin
Ed Churchwell, University of Wisconsin
Mark Wolfire, University of Maryland
Barbara Whitney, Space Science Institute
Christer Watson, Manchester College

Science Category: star formation
Observing Modes: IrsMap
Hours Approved: 14.8

Abstract:
We propose to combine the unique spectroscopic capabilities of Spitzer IRS and the VLA to study possible instances of triggered star formation using a more comprehensive range of diagnostics than ever before. This study is essential to move beyond morphological and photometric color arguments (e.g. the spatial distribution of red sources) for triggered star formation. In particular, Spitzer IRS data will allow us to (I) Determine the ionized gas properties via comprehensive photoionization modeling of the HII region; (II) Perform detailed modeling of the PDR including penetration of UV radiation and heating; (III) Locate and model shocks that may be compressing gas in the triggering zone; and (IV) Tightly constrain the nature and evolutionary state of embedded sources in the rim to see if their age and the distribution of circumstellar material is consistent with formation by triggering. Together with VLA ammonia data (proposed separately) these Spitzer IRS diagnostics will allow us to conclusively determine the nature of the triggering forces (ionized gas pressure and shocks), conditions in the triggered molecular gas, and the natures of the putatively triggered protostars. Moreover, by providing a complete picture of the physical conditions in the ionized, PDR, and molecular gas, these data offer the best chance to date to distinguish between the leading theories for HII region triggering: collect-and-collapse and radiation driven implosion.

Spitzer Space Telescope - Legacy General Observer Proposal #50398

Spitzer Mapping of the Outer Galaxy (SMOG)

Principal Investigator: Sean Carey
Institution: Spitzer Science Center

Technical Contact: Sean Carey, SSC

Co-Investigators:
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Chris Brunt, University of Exeter

Science Category: star formation
Observing Modes: IracMap MipsScan
Hours Approved: 149.0

Abstract:
We propose mapping a 21 square degree area with IRAC and MIPS of a representative region of the outer Galaxy (l=102-109, b=0-3). From these data and previous and future surveys in the submillimeter and millimeter, the specifics (rate, IMF) of star formation of the survey region will be measured. This direct measurement of the star formation efficiency will then be placed in context with ongoing work for the inner Galaxy, nearby molecular clouds and massive star forming regions, the Magellanic clouds and galaxies at larger distances. A set of optimally reduced mosaics and well-characterized source catalogs will be made available to the community. As with previous large Spitzer local group mapping programs, GLIMPSE, MIPSGAL & SAGE, this data set will be a fertile source for studying such topics as evolved stars, Galactic structure, dust physics and the diffuse ISM.

Spitzer Space Telescope - General Observer Proposal #50130

Extended 4.5 micron GLIMPSE Sources: Rapidly Accreting Massive Protostars?

Principal Investigator: Ed Churchwell
Institution: University of Wisconsin

Technical Contact: Ed Churchwell, University of Wisconsin

Co-Investigators:
Christer Watson, Manchester College
Claudia Cyganowski, University of Wisconsin - Madison
Barbara Whitney, Space Science Institute

Science Category: star formation
Observing Modes: IrsMap
Hours Approved: 10.9

Abstract:
We propose to obtain spectral line images, using Spitzer/IRS, toward 11 of 300+ cataloged extended 4.5?m excess sources from the GLIMPSE survey. They are believed to be massive protostars in the earliest stages of rapid accretion accompanied by powerful bipolar outflows. If so, they may represent the earliest stage of massive star formation yet observationally identified, well before their final mass is reached. At present, this is mostly conjecture based on mid-IR spectral energy distributions and associations with massive star formation tracers such as radio masers, location in infrared dark clouds, and HII regions. Infrared spectra are required to establish the nature of these intriguing objects. IRS spectra will permit us to probe the ionization distribution around the central protostar, the shocked gas produced by outflows crashing into the ambient ISM, the PDR associated with the objects, and the properties of the infrared dark clouds in which they are embedded. The objects are small, typically ?20? in extent, and can be imaged in spectral lines with a redundancy of 4 in less than one hour/source. Imaging 10-12 objects is necessary to establish mean properties and their dispersion for this class of objects. The IRS data will be supplemented by sensitive, high resolution radio continuum and molecular line observations from CARMA and the VLA that will provide data on associated molecular gas properties, thermal dust emission, and free-free emission from ionized gas.

Spitzer Space Telescope - General Observer Proposal #50758

Star Formation in the Outer Galaxy

Principal Investigator: Meredith Drosback
Institution: University of Colorado

Technical Contact: Meredith Drosback, University of Colorado

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Miranda Nordhaus, University of Texas, Austin
Erik Rosolowsky, Harvard Center for Astrophysics
Jonathan Williams, University of Hawaii

Science Category: star formation
Observing Modes: IracMap MipsScan
Hours Approved: 13.1

Abstract:
We propose to obtain IRAC and MIPS scans of a well-defined region toward the galactic anti-center. We have 1.1 mm images of the region from the Bolocam Galactic Plane Survey (BGPS), and will use the combined infrared and millimeter wavelength data sets to study the formation of stars in this unique environment. The gas in the outer galaxy has different physical properties, such as metallicity and interstellar pressure, than the more typical star-forming regions in the galactic center thus enabling us to compare the star formation process across a wide range of environments. We will use the combined MIPS, IRAC, and BGPS images to characterize the morphology of the young protostellar cores at various wavelengths. We will measure physical properties such as size and mass, and create continuous spectral energy distributions of these cores from 3.6 microns to 1.1 mm in order to determine their stage of star formation. The mid- and far-infrared images from Spitzer are a crucial piece of this study to elucidate the nature of star formation in the outer galaxy.

Spitzer Space Telescope - General Observer Proposal #30563

Very Low Luminosity Objects: Investigating the Lowest Luminosity, Embedded Protostars with Spectra from 5-100 microns

Principal Investigator: Michael Dunham
Institution: University of Texas at Austin

Technical Contact: Michael Dunham, University of Texas at Austin

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Jes Jorgensen, Harvard-Smithsonian Center for Astrophysics
Subhanjoy Mohanty, Harvard-Smithsonian Center for Astrophysics

Science Category: star formation
Observing Modes: IrsStare MipsSed
Hours Approved: 15.2

Abstract:
One of the most surprising results from the Spitzer Space Telescope Legacy Project "From Molecular Cores to Planet Forming Disks" has been the discovery of a very low luminosity protostar (L ~ 0.1 Lsun) in L1014, a dense core previously believed to be starless. Other, similar objects have now been discovered in other cores as well, leading to the definition of a new class of Very Low Luminosity Objects. These objects are difficult to understand in the standard model of star formation, they either feature mass accretion rates much lower than predicted, masses far below the stellar/substellar boundary, or some combination of the two. Understanding these objects is essential for the development of a complete picture of low-mass star and brown dwarf formation. We propose a project to obtain low-resolution IRS and MIPS SED mode spectra of 17 of these Very Low Luminosity Objects at wavelengths ranging from 5 to 100 microns. These observations will allow us to place constraints on the luminosities of these sources not possible with existing data. This will allow us to confirm the current results suggesting these sources all have luminosities less than or equal to 0.1 Lsun. We will also use the observations to probe the properties of the dust in the regions surrounding these heavily embedded objects. Finally, they will allow us to investigate the presence and properties of circumstellar disks around these objects, and through this, a possible explanation for their very low luminosities.

Spitzer Space Telescope - General Observer Proposal #50295

A Search for Evidence of Episodic Mass Accretion: IRS and MIPS SED Mode Observations of 21 Low-Luminosity, Embedded Protostars

Principal Investigator: Michael Dunham
Institution: University of Texas at Austin

Technical Contact: Michael Dunham, University of Texas at Austin

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Tracy Huard, University of Maryland
Melissa Enoch, University of California, Berkeley

Science Category: star formation
Observing Modes: IrsStare MipsSed
Hours Approved: 28.6

Abstract:
The Spitzer Space Telescope Legacy Project "From Molecular Cores to Planet Forming Disks" (c2d) has completed a 3.6 - 160 micron imaging survey of nearby, low-mass star forming regions. Approximately 50 embedded protostars with luminosities less than 1 solar luminosity have been identified, many of which were not known based on previous lower-sensitivity, lower-resolution surveys (e.g., IRAS). They are difficult to understand in the standard model of star formation, which predicts higher luminosities than observed for these objects. One proposed solution to this problem is that matter accretes from the envelope at a more or less uniform rate, but is stored in the disk for a period of time before accreting onto the star in a short-lived burst. If this process of episodic accretion occurs, the short-lived bursts will heat the surrounding envelope and leave imprints in its chemistry long after the burst ends and the source luminosity and envelope temperature drop. In particular, they will create a component of pure CO_2 ice in an irreversible process; this component can be identified through high-resolution Spitzer-IRS observations. We propose to obtain a complete data set of IRS SH, IRS LL1, and MIPS SED mode spectra for 21 objects with luminosities below 1 Lsun. These data will enable us to search for a component of pure CO_2 ice in the 15.2 micron CO_2 absorption feature, which previous work on higher luminosity (1-10 solar luminosities) sources has already proven to be feasible. We will also obtain accurate constraints on current source luminosities and envelope temperature structures, obtained through models constrained by the IRS and MIPS SED spectra. Combining these studies will allow us to obtain an unambiguous answer to the question of whether or not these sources have featured past accretion bursts.

Spitzer Space Telescope - Directors Discretionary Time Proposal #286

Protosteller Evolution in the Main Accretion Phase

Principal Investigator: Melissa Enoch
Institution: Caltech

Technical Contact: Melissa Enoch, Caltech

Science Category: star formation
Observing Modes: IrsStare
Hours Approved: 12.3

Abstract:
I will focus my research on the evolution of the most deeply embedded protostellar objects in their main accretion phase. The projects outlined in my proposal are designed to study the lifetime of the main accretion phase, the innermost envelope structure, the timescale for disk formation, and the disk-to-envelope mass fraction in young protostars. My research will utilize archival Spitzer Legacy data, primarily from the Cores to Disks Legacy Project, as well as proposing new Spitzer IRS and CARMA millimeter interferometric observations of highly embedded protostars.

Spitzer Space Telescope - Directors Discretionary Time Proposal #50536

Detecting the First Hydrostatic Core with Deep 70 micron Imaging

Principal Investigator: Melissa Enoch
Institution: Caltech

Technical Contact: Melissa Enoch, Caltech

Co-Investigators:
Jeong-Eun Lee, Sejong University, Korea
Michael Dunham, University of Texas, Austin
Paul Harvey, University of Texas, Austin

Science Category: star formation
Observing Modes: MipsPhot
Hours Approved: 7.8

Abstract:
We propose to complete deep 70 micron imaging of 7 first hydrostatic core (FHSC) candidates. Intermediate between the prestellar and Class 0 protostar phases, the FHSC is a transient, quasi-equilibrium core of molecular hydrogen accreting from the surrounding dense envelope; the lifetime of this FHSC is only 1e3 - 3e4 years. The FHSC phase has not yet been observationally verified, and MIPS is the only far-IR instrument currently sensitive enough to detect it. Candidates are chosen from a sample of dense starless cores in the Perseus, Serpens, and Ophiuchus molecular clouds, which was assembled using the combination of Spitzer IRAC and MIPS maps from the c2d Legacy program and Bolocam 1.1 mm continuum maps. We intend to integrate down to nearly the confusion limit at 70 micron, with a 1 sigma rms of 1.5 - 2.8 mJy and improved sensitivity over previous c2d maps by a factor of 10. The proposed observations are sensitive enough to detect a FHSC over more than 70% of its lifetime, based on predictions from radiative transfer models. Predicted fluxes from these models suggest that deep 70 micron imaging will either confirm the existence of this short-lived phase of the star formation process, or place strong constraints on the presence of a FHSC in these targets. This is a relatively high-risk, high-gain project that requires the unique capabilities of the cold Spitzer 70 micron array.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #46

Deep IRAC Imaging of High Mass Protostars

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Tom Megeath, Harvard, CfA

Science Category: Star Formation
Observing Modes: IracMap IrsMap
Hours Approved: 3.2

Abstract:
We will perform deep IRAC imaging of three high mass star forming regions: M17SW, NGC 6334 I, and NGC 281West. All three regions are known to contain deeply embedded high mass protostars in regions where the extinction is in excess of 50 AV. We will probe these high extinction regions for deeply embedded low mass stars. From this measurement, we can estimate the stellar densities in the immediate vicinities of forming high mass stars and test theories which explain the formation of high mass stars through collisions of lower mass stars.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30050

Star Formation in Bright Rimmed Clouds

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Lori Allen, Smithsonian Astrophysical Observatory

Co-Investigators:
Lori Allen, SAO
Sean Carey, SSC
Tom Megeath, Univ. of Toledo
Chris De Vries, Cal State Stanislaus

Science Category: star formation
Observing Modes: IracMap MipsPhot
Hours Approved: 3.8

Abstract:
Bright-rimmed clouds (BRCs) are small, isolated molecular gas clouds with at least one edge ionized by neighboring OB stars. Because of their compact nature and physical isolation from the more turbulent star forming regions in giant molecular clouds, they are excellent laboratories for the study of triggered star formation. The goal of this program is to obtain a complete census of protostars and young stars in a distance-limited sample of BRCs. The spatial distributions of the embedded protostars and young stars will be analyzed for signatures of sequential, or triggered, star formation. We propose to image a sample of 13 BRCs in the four IRAC bands and in the 24 and 70 micron bands of MIPS. The sample is drawn from that of Sugitani et al. (1991, 1994) for BRCs within 1 kpc of the Sun. The proposed observations will have sufficient sensitivity to reliably detect the entire T-Tauri population within the sample, sub-stellar mass objects well into the brown dwarf regime, and Class 0 protostars down to 0.5 solar masses. They will provide, for the first time, a complete census of the space and luminosity distributions of young stars within these clouds.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30335

Census of the Embedded Population of the Vela Molecular Remnant Cloud-D

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Massimo Marengo, Harvard-CfA

Co-Investigators:
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Alessio Caratti o Garatti, INAF, Oss. Astronomico di Roma

Science Category: star formation
Observing Modes: IracMap MipsScan
Hours Approved: 11.3

Abstract:
We propose to exploit the large-scale, high-sensitivity imaging capabilities of IRAC and MIPS on board SPITZER in order to perform a deep IR survey toward a molecular cloud (D) in the Vela Molecular Ridge (VMR-D). This cloud hosts a large number of young embedded sources, both in clusters and isolated, as well as mm-emission peaks associated with gaseous filamentary structure, discovered by our ground based near-IR and mm observations. By correlating the SPITZER maps with the existing data, our aims are (i) to identify and classify, from the combined NIR, mid-IR and mm SEDs, the embedded young object population of the cloud. This will be used to characterize the protostellar content and to understand the effects of the environments on the star forming process; (ii) to obtain an unbiased map of the protostellar jets distribution through the detection of shocked emission lines falling in the IRAC filters; (iii) to define a sample of well selected proto-stellar objects located in the southern hemisphere for future interferometric follow-up with ALMA.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30641

Extending the Spitzer Orion Molecular Cloud Survey

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Tom Megeath, Harvard, CfA

Co-Investigators:
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Joe Hora, SAO
Rob Gutermuth, SAO
Lee Hartmann, University of Michigan
Phil Myers, SAO
John Stauffer, SSC
James Muzerolle, University of Arizona
Erick Young, University of Arizona

Science Category: star formation
Observing Modes: IracMap MipsScan
Hours Approved: 21.0

Abstract:
The Orion Molecular Cloud Complex is the most active region of star formation within 500 pc sun, containing several sites of high mass star formation, the largest known embedded cluster in the nearest 1 kpc, and over 2000 low mass stars. As part of the IRAC and MIPS instrument team Guaranteed Time Programs, we have surveyed 7.7 sq degrees with the IRAC and MIPS instrument. Using this data, we have surveyed the cloud for young stars with disks and protostars, and have mapped the distribution of over 2000 objects. We propose to extend this map with two goals: 1.) to map the extended halo of young stars surrounding the Orion Nebula Cluster in order to constrain the dynamical evolution of this cluster, and 2.) to map relatively quiescent sub-clouds of the Orion B cloud in order to better understand the importance of triggering in this cloud.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30784

IRAC GTO Map Extensions

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Lori Allen, Smithsonian Astrophysical Observatory

Co-Investigators:
Tom Megeath, Univ. Toledo
Joe Hora, SAO
Luis Chavarria, SAO

Science Category: star formation
Observing Modes: IracMap MipsScan
Hours Approved: 7.0

Abstract:
We propose to extend the IRAC and MIPS maps of star--forming regions in IRAC GTO programs 6 (Embedded Clusters Survey) and 201 (Infrared Photodissociation Regions). The proposed observations will double the size of our existing map in Corona Australis, and add small but critical areas to the maps of S235, S255, and NGC7538.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40056

Search for star-formation in Lynds opacity class 6 clouds

Principal Investigator: Giovanni Fazio
Institution: Smithsonian Astrophysical Observatory

Technical Contact: Babar Ali, California Institute of Technology

Co-Investigators:
Lori Allen, Harvard-Smithsonian Center for Astrophysics
John Stauffer, Caltech/IPAC
Luisa Rebull, Caltech/IPAC

Science Category: star formation
Observing Modes: IracMap MipsScan
Hours Approved: 10.0

Abstract:
This proposal seeks to survey 3 Lynds dark clouds using IRAC and MIPS. The primary aim of this study is to search for signs of star-formation, particularly for the lowest-mass proto-stars and brown dwarfs. The study is motivated by recent results from Spitzer that suggest that the so-called "starless" cores may not necessarily be starless. In this proposal, we are taking advantage of the opportunity provided by Spitzer to extend the sample of starless cores to include those that have received little or no attention, usually due to observer biases towards cores with bright star-formation markers (eg. associated IRAS sources). Results from the proposed observations have direct implications for how the low-mass end of the initial mass function is populated in the Galaxy as well as on the lifetimes and evolution of dark cores. In the light of the recent Spitzer results, and the exciting science they will make possible, these clouds now merit a much closer look.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40147

Clusters Near Clusters

Principal Investigator: Giovanni Fazio
Institution: Smithsonian Astrophysical Observatory

Technical Contact: Robert Gutermuth, SAO

Co-Investigators:
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Phil Myers, Smithsonian Astrophysical Observatory
Judy Pipher, University of Rochester
Lori Allen, Smithsonian Astrophysical Observatory

Science Category: star formation
Observing Modes: IracMap MipsScan
Hours Approved: 22.9

Abstract:
A systematic search through the Spitzer GTO Young Cluster Survey IRAC, MIPS, and ancillary data has revealed that the coverage of some primary target clusters of young stellar objects as well as several newly discovered nearby secondary groups is spatially incomplete, truncating the full extent of these clusters as revealed by Spitzer. We propose IRAC and MIPS survey extensions to expand coverage of exceptionally large primary targets and newly discovered nearby secondary groups of young stellar objects found in the Spitzer GTO Young Cluster Survey.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40402

W5 Map Extension

Principal Investigator: Giovanni Fazio
Institution: Smithsonian Astrophysical Observatory

Technical Contact: Lori Allen, Smithsonian Astrophysical Observatory

Co-Investigators:
Lori Allen, SAO
Xavier Koenig, Harvard University
Joseph Hora, SAO

Science Category: star formation
Observing Modes: IracMap MipsScan
Hours Approved: 3.9

Abstract:
We propose one IRAC map and two MIPS scan maps to extend (and complete) our map of W5. Previous MIPS observations (PID20300) just missed the deeply embedded star formation on the eastern--most edge of the HII region. One of the proposed MIPS observations will cover this region, matching our IRAC coverage. The second MIPS AOR will fill a narrow gap in the middle of our map at 70 microns, enabling us to complete our analysis of the dust emission in the bright rim surrounding W5. The current gap unfortunately passes along a ridge of 70 micron emission, where the two HII region bubble walls meet. The IRAC map covers the northeast corner of the bright rim, completing our map.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40440

Subarray observations of bright young stars

Principal Investigator: Giovanni Fazio
Institution: Smithsonian Astrophysical Observatory

Technical Contact: Luis Chavarria, Smithsonian Astrophysical Observatory

Co-Investigators:
Luis Chavarria, SAO
Lori Alllen, SAO
Joseph Hora, SAO

Science Category: star formation
Observing Modes: IracMap
Hours Approved: 0.4

Abstract:
We propose to carry out IRAC subarray imaging of bright embedded stars in three of the high mass star forming regions previously imaged with IRAC: S255, NGC7538 and AFGL4029. All three regions contain deeply embedded high mass protostars in high extinction molecular clouds. These subarray mode observations will enable us to obtain unsaturated measurements of the massive protostars and to probe these high extinction regions for deeply embedded associated stars. From this measurement, we can estimate the stellar densities in the immediate vicinities of forming high mass stars and test theories which explain the formation of high mass stars through collisions of lower mass stars.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40448

Deep imaging of rich clusters in W5

Principal Investigator: Giovanni Fazio
Institution: Smithsonian Astrophysical Observatory

Technical Contact: Xavier Koenig, Harvard-SAO

Co-Investigators:
Xavier Koenig, Harvard-Smithsonian Center for Astrophysics
Lori Allen, Smithsonian Astrophysical Observatory
Joseph Hora, SAO

Science Category: star formation
Observing Modes: IracMap
Hours Approved: 10.7

Abstract:
W5 is part of the well-known chain of large HII regions in the Perseus arm, W3/W4/W5; however it is well segregated from W3/W4. At a distance of 2 kpc, W5 is comprised of multiple overlapping bubbles of ionized gas, extending over 2 x 1.5 degrees on the sky. We have recently uncovered previously unknown dense clusters surrounding massive O stars in the interior of the W5 star forming region with IRAC and MIPS observations. We propose to obtain deep images of these clusters with IRAC in an effort to improve both the signal to noise of the stars we detect in these clusters, and the spatial resolution of our observations. This will help us to compare more directly with our near-IR and optical data for the same dense clusters, and better understand their mass functions and ages. This in turn will enable us to measure more accurately the age sequence of star clusters across all of W5 and understand if triggering is a possible mechanism to explain this sequence. The proposed observations will improve the sensitivity of our existing IRAC observations by a factor of 4.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50026

MIPS and IRAC Imaging of High Mass Protostellar Cores

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Howard Smith, Harvard-SAO

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Joe Hora, CfA
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Fabiani Faustini, IFSI-Roma
Barbara Whitney, Space Science Institute
Murray Campbell, Colby College

Science Category: star formation
Observing Modes: IracMap MipsPhot
Hours Approved: 11.0

Abstract:
We propose an infrared study of a thorough set of 140 embedded high mass protostellar cores (HMPOs) that span a range of early types. Our sample is selected from well-studied objects in our previous cm/mm/IR wavelength programs. Most of our embedded core sources are undetected at [K], but are seen by IRAC Band 4 and MSX; all are associated with IRAS luminous sources, and most have some associated molecular outflow. We have limited this sample to those cores probably closer than 5kpc. We propose Spitzer MIPS70 pointed super resolution observations of the 55 sources in our sample that have had no previous MIPS 70um observations; we propose MIPS24 on 29 of these that are unlikely to saturate; and we propose IRAC imaging on 30 with no previous IRAC observations and whose IRAS colors are indicative of stellar neighbors that we want to spatially resolve. We will use these data, to study systematically the character of these high mass protostellar cores. Our team has recently published two new papers on the SEDs of individual objects in our full sample that had been previously observed. Our program includes extensive SED modelling, and the team includes experts in modeling.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50045

Spectra of Massive Young Stars in the Cygnus-X Complex

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Joseph Hora, Harvard-SAO

Co-Investigators:
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Tom Megeath, University of Toledo
Nicola Schneider, CEA/Saclay
Frederique Motte, CEA/Saclay
Sean Carey, Spitzer Science Center
Robert Simon, University of Cologne
Eric Keto, CfA
Howard Smith, CfA
Lori Allen, CfA
Rob Gutermuth, CfA
Kathleen Kraemer, AFRL
Don Mizuno, AFRL
Stephan Price, AFRL
Joseph Adams, Cornell University

Science Category: star formation
Observing Modes: IrsMap
Hours Approved: 20.0

Abstract:
We propose to use the IRS to obtain 5-40 um spectra of a sample of massive stars that are forming in the Cygnus-X region. Cygnus-X is the richest known region in IR-luminous and IR-quiet massive protostars within 2 kpc, and thus is a unique laboratory to study the poorly constrained early stages of massive star formation. The sample will be selected mainly from MSX sources and IR-quiet millimeter continuum sources, and will contain objects with a range of masses and at various stages of evolution. These data will enable us to determine how the properties of these massive stars change as they evolve towards the main sequence. We will also be able to examine the effects that these stars are having on their surroundings, including outflows into the nearby ISM and also in triggering further star formation.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50070

Probing the Interaction of a Supergiant and the Orion A Molecular Cloud: The Kappa Ori Ring

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Tom Megeath, Ritter Observatory, University of Toledo

Co-Investigators:
Tom Megeath, University of Toledo
Lori Allen, Harvard Smithsonian CfA
John Stauffer, SSC
Erick Young, Steward Observatory
Phil Myers, Harvard Smithsonian CfA
Rob Gutermuth, Harvard Smithsonian CfA
Judy Pipher, University of Rochester
Lee Hartmann, University of Michigan
James Muzerolle, Steward Observatory

Science Category: star formation
Observing Modes: IracMap MipsScan
Hours Approved: 13.8

Abstract:
The Orion A cloud is the most active giant molecular cloud with 500 pc of the Sun. The molecular cloud was surveyed as part of the GTO program with the IRAC and MIPS instruments; these data provided an unbiased census of protostars and young stars in all the environments. This survey found large numbers of relative isolated stars in uncrowded environments parsecs away from the young OB stars in the Orion Nebula. However, recent maps of the molecular cloud show that the Orion A cloud extends further south than previous thought and that only 3/4 of the cloud was mapped in the previous survey. Furthemore, the southern extension of this cloud forms a ring around the B1I star Kappa Ori (or Saiph). We propose to map this region to complete the unbiased survey of the Orion A cloud, to determine if Saiph is indeed interacting with Orion A, and if so, to measure the impact of that interaction on star formation in the Orion A cloud.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50109

Completing the Census of Embedded Population in the Vela Molecular Ridge Cloud-D

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Massimo Marengo, Harvard-SAO

Co-Investigators:
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Massimo De Luca, INAF Oss. Astronomico di Roma
Fabrizio Massi, INAF Oss. Astronomico di Arcetri
Davide Elia, Universita del Salento - Lecce
Francesco Strafella, Universita del Salento - Lecce

Science Category: star formation
Observing Modes: IracMap
Hours Approved: 4.0

Abstract:
The Vela Molecular Ridge is a molecular cloud in the galactic plane at high galactic longitude (l~260-275 deg). Part of a vast complex of star forming region, it hosts a large number of young embedded sources, both in cluster and isolated, as well as mm-emission peaks associated with gaseous filamentary structures. These characteristics makes it perhaps the best regions for testing scenarios of clustered star formation outside the solar circle. In Cycle 3 we have obtained MIPS observations of the cloud, that have led to important results concerning the statistics of embedded cores and their relationship with the diffuse gas and dust in the region. We have also obtained partial coverage with IRAC for 4 out of 6 of the clusters in the complex. We propose here to: (1) complete the IRAC coverage for the remaining 2 clusters, (2) obtain IRAC maps of two background fields in a region devoted of molecular gas and dust and (3) measure the photometry of a cluster that was saturated in our previous IRAC images using the subarray mode. These new observations are crucial for the completeness of our census of the YSO population in the cloud, and to remove biases in the statistics of the distribution of the sources detected in the previous observations.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50264

Deep IRAC Imaging of Mocular Outflows in High-Mass Star Forming Regions

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Keping Qiu, Harvard-SAO

Co-Investigators:
Qizhou Zhang, Harvard-Smithsonian Astrophysical Observatory

Science Category: star formation
Observing Modes: IracMap
Hours Approved: 4.9

Abstract:
Recent single-dish CO observations have proven that massive molecular outflows are ubiquitous toward high-mass star forming regions. It is essential to understand them as a step toward understanding massive star formation. However, in contrast to outflows from low-mass stars, many important properties of outflows from high-mass stars remain unknown, partly due to the poor statistics of high angular resolution observations. The Spitzer/IRAC imaging provides a completely independent means of mapping outflows. As a continuation of our successful GO observations, here we propose for GTO observations to image outflows in 18 high-mass star forming regions with the Spitzer/IRAC. The sources are chosen from our ongoing SMA projects dedicated to a systematic study of molecular outflows and accretion in high-mass protostellar objects. Combining the proposed observations and our SMA data, we will be able to carry out a systematic study of outflows from high-mass stars based on high angular resolution observations at mid-IR and (sub)millimeter wavelengths. A detailed comparison between our observations and well studied low-mass outflows will show us whether outflows from high-mass stars are simply scaled-up versions of outflows from low-mass stars and put tighter constraints on theoretical models of massive star formtion.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50452

A Survey for Isolated Clusters in Bok Globules

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Dawn Peterson, Harvard-SAO

Co-Investigators:
Lori Allen, Harvard-Smithsonian Astrophysical Observatory
Robert Gutermuth, Harvard-Smithsonian Astrophysical Observatory
Tyler Bourke, Harvard-Smithsonian Astrophysical Observatory

Science Category: star formation
Observing Modes: IracMap MipsScan
Hours Approved: 14.3

Abstract:
We propose Spitzer IRAC and MIPS observations of a sample of 11 Bok globules in order to detect deeply embedded infrared sources and determine whether they are sites of active star formation. Small groups of stars forming in these Bok globules are unique because they are forming in a relatively isolated environment. Many of the sources in the sample of Bok globules chosen are forming stars, as evidenced by radio or infrared IRAS sources. The proposed sample includes Bok globules surveyed for 3.6 cm continuum emission with the VLA (Yun et al. 1996; Moreira et al. 1999). However, a complete census of the stellar content of these regions is needed in order to probe the intial conditions necessary for low mass star formation. The Spitzer observations will, in addition to ground-based near-infrared imaging from 2MASS (or deeper in the case of more distant regions), allow us to construct spectral energy distributions from 1-70 micron for all sources detected in or nearby the Bok globules, determining whether they harbor circumstellar disks indicative of Class I and II sources.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50519

An Unbiased Survey of the Gem OB1 Molecular Cloud Complex

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Lori Allen, Harvard-SAO

Co-Investigators:
Lori Allen, SAO
Robert Gutermuth, SAO
Dawn Peterson, SAO
Tom Megeath, University of Toledo
James Muzerolle, University of Arizona

Science Category: star formation
Observing Modes: MipsScan
Hours Approved: 43.2

Abstract:
We propose an unbiased 24 micron survey of the Giant Molecular Cloud complex known as Gem~OB1. Unlike the nearby dark clouds surveyed by Spitzer Legacy teams, GMCs are responsible for most of the star formation in the Galaxy and therefore are more representative of the typical birthplace of stars. The Gem~OB1 cloud lies toward the outer Galaxy where the Galactic background and line-of sight extinction are both low, and near enough that its solar-mass protostars are easily detectable by Spitzer. Gem~OB1 is notable for its multiple bubble like structures and other complex morphologies seen in molecular gas. The proposed 24 micron data will be used to identify protostars throughout the cloud, and will be combined with data from subsequent surveys to study the distribution of T-Tauri stars, the evolution of protostellar envelopes and disks, and the demographics of stellar masses and ages in the Gem~OB1 GMC. The proposed 24 micron measurements are essential for identifying embedded protostars, and for characterizing disk evolution, especially in older systems that are evolving from protoplanetary to debris disks. This survey will "set the stage" for a Spitzer warm mission follow-up project, aimed at further characterizing the young stars in Gem~OB1.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50533

Distributed vs. Clustered Star Formation in Cam OB-1

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Judy Pipher, University of Rochester

Co-Investigators:
Robert Gutermuth, Smithsonian Astrophysical Observatory
S. Thomas Megeath, University of Toledo
Lori Allen, Smithsonian Astrophysical Observatory
Phillip Myers, Smithsonian Astrophysical Observatory

Science Category: star formation
Observing Modes: MipsScan
Hours Approved: 16.1

Abstract:
The accepted paradigm in OB associations is that both high and low mass stars form predominantly in clusters containing 100s to 1000s of members. We have been re-examining that paradigm by identifying forming stars (protostars and stars with circumstellar disks) in GMCs via their infrared excesses at mid-IR and near-IR wavelengths, and studying the projected spatial distribution of those stars and their relative frequency as a function of physical parameters of the cloud such as luminosity, local gas and dust density, age, dynamical effects, among others. We are also comparing star formation in GMCs preferentially harboring low mass stars with these higher mass analogues, in order to identify differing evolutionary behaviors. The question of whether the distributed stellar population formed in situ, or was expelled from clusters, is the main driver for this proposal. Cam OB-1 is a lower luminosity (by factors of 10 or greater) example than most other associations in GMCs studied by us to date, including NGC 2264, Cep OB3, Mon R2, and Orion. A sufficiently large sample of high mass star forming GMCs is necessary to disentangle influence of various effects. Here we request MIPS observations to study the protostellar population in Cam OB1. Near IR Ks-band excess objects (mainly stars with disks) are more uniformly distributed in Cam OB1 than in other clouds in our sample. We are interested here to assess whether the protostars are also a larger percentage of the distributed population. We will propose to obtain 3.6 and 4.5 micron maps of Cam OB1 in a post-cryo mission, thus completing a sensitive, Spitzer enabled analysis of the YSO spatial distribution as an input to answering the driving question mentioned above.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50691

L1340: How Do Intermediate-Mass Stars Impact Their Natal Environment?

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: JoAnn O'Linger, Spitzer Science Center

Co-Investigators:
Grace Wolf-Chase, Adler Planetarium/Univ. of Chicago
Sean Carey, Spitzer Science Center
Gerald Moriarty-Schieven, Joint Astronomy Centre
Mary Barsony, Space Science Institute/SFSU
Maria Kun, Konkoly Observatory of the Hungarian Academy of Sc
Michael Ressler, Jet Propulsion Laboratory

Science Category: star formation
Observing Modes: IracMap MipsScan
Hours Approved: 4.9

Abstract:
L1340 is a mid-Galactic-latitude (b~11.5) star-forming cloud which contains several intermediate-mass stars of spectral types B5 and later. It is an ideal testbed for studying the effects such stars have on an isolated, compact cloud. L1340 was specifically chosen to bridge the gap between Spitzer studies of low- and high-mass star formation modes in other clouds. Through ground-based multi-wavelength continuum and spectral line observations, we have found a series of bubble-like structures within this cloud that appear to be associated with the intermediate-mass stars. Additionally, we have imaged dozens of cold dust cores around the edges of these structures using SCUBA, many of which exhibit outflow activity and other hallmarks of extreme youth. These features make L1340 unique among known molecular clouds within 600 parsecs. Therefore we propose to map the L1340 cloud with IRAC and MIPS in order to: 1) Investigate the prevalence of "bubbles within bubbles" in this relatively nearby, isolated, intermediate-mass star-forming cloud. 2) Take a complete census of the protostellar population associated with our submillimeter cores using the unprecedented sensitivity of IRAC and MIPS. 3) Analyze the spatial distributions of Young Stellar Objects (YSOs) within the cloud boundaries for indications of possible sequential, or triggered, star formation.

Spitzer Space Telescope - Theoretical Research Proposal #40515

Star Formation Ecology: YSO Outflow Feedback in Young Clusters

Principal Investigator: Adam Frank
Institution: University of Rochester

Technical Contact: Adam Frank, University of Rochester

Co-Investigators:
John Bally, University of Colorado
Alice Quillen, University of Rochester
Eric Blackman, University of Rochester
Judy Pipher, University of Rochester
Robert Gutermuth, SAO

Science Category: star formation
Dollars Approved: 89317.0

Abstract:
Energetic outflows associated with young stellar objects exert a strong effect on their parent molecular clouds. The dynamics of this interaction is yet to be well understood. In particular the role of jets and outflows in powering cloud turbulence, modifying the star formation efficiency (SFE) and/or disrupting the parent clouds remains unclear. Spitzer images of young clusters have provided new views of jet-cloud interactions that can help resolve these critical issues. In this proposal we seek to continue a highly successful (cycle 2) theory program to explore theoretical issues of jet-cloud interactions, turbulence and cloud disruption. Our research relies on 3-D Adaptive Mesh Refinement hydrodynamic and MHD simulations developed in house, in concert with Spitzer databases and other complementary observations. The team we have assembled includes computational and analytic theorists (Frank, Blackman) as well as observers who have worked closely with existing Spitzer Datasets (Bally, Quillen, Pipher, Gutermuth) The work funded through the previous TR program revealed fundamentally new aspects of YSO outflow feedback on parent cloud cores including the importance of the temporal evolution of outflow power. In this proposal we seek to extend the understanding gained in those studies to address specific questions on the nature and efficacy of outflow feedback in real systems.

Spitzer Space Telescope - General Observer Proposal #40500

Probing the initial phases of cluster formation in an outer Galaxy dark cloud

Principal Investigator: Wilfred Frieswijk
Institution: Kapteyn Astronomical Institute, SRON

Technical Contact: Wilfred Frieswijk, Kapteyn Astronomical Institute, SRON

Co-Investigators:
Sean Carey, Spitzer Science Center, Caltech
Marco Spaans, Kapteyn Astronomical Institute
Russell Shipman, SRON
Xander Tielens, NASA Ames Research Center
David Teyssier, ESAC

Science Category: star formation
Observing Modes: IracMap MipsPhot
Hours Approved: 5.5

Abstract:
As the discovery of InfraRed Dark Cloud in silhouette against bright background IR emission demonstrates, massive cores, characterized by large column densities of dense molecular material, are ubiquitous in the Galaxy. While initially these clouds were thought to represent the prestellar core phase of stellar cluster formation, the high sensitivity of the IRAC and MIPS instruments on Spitzer have recently revealed deeply embedded objects in several of these clouds. Up to now, such dense, massive cores were predominantly known towards the inner Galaxy where background IR emission levels are high, but this selection may carry with it various selection effects. Recently, we completed an unbiased survey of massive dense clouds in the outer Galaxy based upon near-IR color deviation studies using the 2MASS Point Source Catalog. Object OGDC111.80+0.58, selected from this survey, is a large (>10 pc), filamentary molecular cloud complex in a very young stage of evolution and contains multiple massive (50-1000 Msun) cores. We propose to study the star formation characteristics of this complex structure using IRAC and MIPS. Using color-color plots, we can obtain a census of the protostellar population (eg., class 0, I, II, III) in the cores and along the filaments. In addition, analysis of this data will allow us to separate out reddened background stars. This will provide better estimates of the dust column, particularly in the densest cores where background sources extinguished even in the near-IR. Moreover, we expect that a fair fraction of the cores will be starless and this study may well provide the best way to select this ever-elusive first stage of the star formation process.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #127

IRAC and MIPS Images of W3

Principal Investigator: Robert Gehrz
Institution: University of Minnesota

Technical Contact: Elisha Polomski, University of Minnesota

Science Category: Star Formation
Observing Modes: IracMap MipsScan
Hours Approved: 3.2

Abstract:
We will obtain IRAC and MIPS images of the region of star formation W3 to study the distribution and initial mass function of the embedded sources.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #128

IRAC and IRS Observations of Nearby Dwarf Irregular Galaxies

Principal Investigator: Robert Gehrz
Institution: University of Minnesota

Technical Contact: Elisha Polomski, University of Minnesota

Science Category: Star Formation
Observing Modes: IracMap IrsStare
Hours Approved: 15.7

Abstract:
We will conduct mid-IR imaging with IRAC at 4.5 and 8.0 microns to survey the stellar population for embedded stars what would not be identifiable in optical surveys. Mid-IR spectroscopy with IRS in low resolution covering the wavelength range from 5 to 40 microns will be used to obtain spatially resolved spectra of the mid-IR nebular emission lines and the PAH lines in a small sample of well-studied, nearby dwarf starburst galaxies. Mid-IR spectroscopy with IRS in high resolution covering the low wavelength range from 10 to 19.5 microns to search for the molecular hydrogen emission at 0-0 S(1) 17 microns and 0-0 S(2) 12.3 microns in low metallicity environments.

Spitzer Space Telescope - General Observer Proposal #40365

Triggered star formation in the mysterious high-latitude cometary globule CG 12

Principal Investigator: Konstantin Getman
Institution: Pennsylvania State University

Technical Contact: Konstantin Getman, Pennsylvania State University

Co-Investigators:
Eric Feigelson, Penn State
Kevin Luhman, Penn State
Warrick Lawson, University of New South Wales at ADFA

Science Category: star formation
Observing Modes: IracMap
Hours Approved: 7.4

Abstract:
We propose a Spitzer/IRAC mosaic of the mysterious high-latitude cometary globule CG 12. This will complement our recent Chandra and optical study which revealed a rich population of >50 pre-main sequence stars, many located in front of the globule, in addition to the few previously known intermediate-mass members. Our Spitzer program has three observational goals: 1. to study the protoplanetary disk evolution in both obscured and irradiated locations using the disk-unbiased X-ray sample; 2. to discover new low-mass infrared-excess members of the cluster which were missed by the Chandra observations; 3. to investigate the nature of its star formation (triggered vs. self-gravitational collapse), which may shed light on the unusual origin and evolution of this CG.

Spitzer Space Telescope - General Observer Proposal #20506

A Detailed Comparison of the Modes of Star Formation in G305.35+0.7 and NGC 2174/5

Principal Investigator: Jeff Hester
Institution: Arizona State University

Technical Contact: Angela Cotera, SETI

Co-Investigators:
Angela Cotera, SETI Inst.
Janet Simpson, NASA Ames
Barbara Whitney, Space Science Inst.
Kevin Healy, Arizona State U.
Keely Snider, Arizona State U.

Science Category: Star Formation
Observing Modes: IracMap IrsStare
Hours Approved: 22.8

Abstract:
Some low-mass stars form in regions of isolated star formation, such as the nearby Taurus-Auriga molecular cloud. Others form instead in regions surrounding massive stars. There are a number of indications that the process of star formation itself may different in important ways depending on the details of the larger environment. In particular, while much star formation seems to be the result of hierarchical collapse and fragmentation in isolated cloud cores, both low- and high-mass star formation in other regions appears to be triggered by compression of gas in advance of expanding ionization fronts around massive stars. There are many implications of these differences, ranging from the origin of the IMF to our understanding of the environment in which the Sun and Solar System formed and evolved. In this proposal we request time to conduct a detailed MIPS/IRAC/IRS investigation of G305.35+0.07 and NGC 2174/5, comparing and contrasting star formation between the two regions. The morphology of one of these regions (G305.35+0.07) is strongly suggestive of triggered star formation in a shell around massive stars, while the other region (NGC2174/5) consists of several apparently detached clusters that might have formed instead through heirarchical collapse. Studies of the distribution of low-mass protostars in these regions, and especially the extent to which they are concentrated in compressed gas around the periphery of each region, will allow us to discriminate between triggered and untriggered star formation. Among our goals is determining whether overt morphological characteristics of H II regions are reliable indicators of the nature of low-mass star formation in these regions.

Spitzer Space Telescope - General Observer Proposal #20726

Spitzer Follow-up of HST Observations of Star Formation in H II Regions

Principal Investigator: Jeff Hester
Institution: Arizona State University

Technical Contact: Keely Snider, Arizona State University

Co-Investigators:
John Bally, University of Colorado
Steve Desch, Arizona State University
Kevin Healy, Arizona State University
Keely Snider, Arizona State University

Science Category: Star Formation
Observing Modes: IracMap MipsPhot
Hours Approved: 27.7

Abstract:
Images of regions of star formation taken with HST have given us an extraordinary view of young stellar objects and their natal environments. These views differ tremendously between low-mass YSOs seen in regions of isolated low-mass star formation such as Taurus-Auriga, and the proplyds, EGGs, and other structures seen in regions of massive star formation. While YSOs in Taurus spend their adolescence buried in the dark interiors of molecular clouds, YSOs near massive stars quickly find themselves overrun by ionization fronts and exposed to the intense UV radiation from nearby massive stars. This difference in environment has a profound effect on the way in which the protoplanetary disk around a star evolves -- a fact that is of great importance to us, given the strength of the evidence suggesting that the Sun formed near a massive star. But HST while HST can inform us about the evolution of YSOs in HII region environments once they are overrun by ionization fronts, it cannot show us the birth of the stars themselves. These remain hidden in the dense molecular material beyond the ionized volumes of these regions. Only Spitzer can show us the properties of the YSOs that lie hidden in the dark shadows of HST images of HII regions, and only Spitzer can provide us with information about PDRs, warm dust, and other tracers of the interaction of massive stars with their surroundings. The combination of HST and Spitzer observations of star forming regions is far greater than the sum of its parts. If we are to build a complete picture of low-mass star formation and the evolution of disks near massive stars, we need to combine HST and Spitzer observations of the same regions. In this proposal we request time to obtain both IRAC and MIPS 24 micron images of each HII region that has been observed by HST, but has yet to be observed with Spitzer. Together with previous images obtained from the archives, this will comprise an indispensible data set for testing hypotheses about this important process.

Spitzer Space Telescope - Archive Research Proposal #30767

Archival Study of the Effects of Massive Stars on Low-mass Star Formation and Disk Evolution

Principal Investigator: Jeff Hester
Institution: Arizona State University

Technical Contact: Jeff Hester, Arizona State University

Co-Investigators:
Barbara Whitney, Space Science Institute
Keely Snider, Arizona State University

Science Category: star formation
Dollars Approved: 90040.0

Abstract:
Most low-mass stars form in close proximity to massive stars, but we lack a good understanding of how those massive stars modify the way low-mass stars and their disks form and evolve. We request Archival support to address three fundamental questions: (1) To what extent is low-mass star formation triggered by massive stars? (2) Does continuing expansion of H II regions terminate accretion after star formation as begun? And (3) to what extent is the evolution stellar disks modified by proximity to massive stars? Studies of individual objects in the literature provide anecdotal evidence for each of these processes, but to date there has been no systematic study of the overall significance of the effects of massive stars on low-mass star formation. Data from the GLIMPSE, GLIMPSE II, and MIPSGAL projects allow such a study to be carried out. In each case the question boils down to one of the association between low-mass YSOs and tracers of the influence of massive stars. If most low-mass star formation is triggered, then most low-mass YSOs will be found in compressed gas surrounding H II regions. If H II region expansion affects accretion, then many low-mass YSOs will be found in regions that will be overrun by ionization fronts within a few hundred thousand years. Finally the distribution of distances between low-mass YSOs and massive stars provides insight into how YSO disks are influenced by UV and supernova ejecta from massive stars. Working on a subsample of the GLIMPSE data we have demonstrated the feasibility of such a study, and have seen early indications that the results will be of great interest. Contours of surface density of sources selected on the basis of IRAC colors closely follow tracers of ionization fronts, PDRs, and compressed gas in the sample fields. The answers to these cleanly posed observational questions bear on many fundamental issues ranging from the origin of the IMF to the evolution of the environment in which the birth of the Solar System took place.

Spitzer Space Telescope - Legacy General Observer Proposal #40184

A Spitzer Legacy Survey of the Cygnus-X Complex

Principal Investigator: Joseph Hora
Institution: Harvard-Smithsonian Center for Astrophysics

Technical Contact: Joseph Hora, Harvard-CfA

Co-Investigators:
Sylvain Bontemps, Observatoire de Bordeaux
Tom Megeath, University of Toledo
Nicola Schneider, CEA/Saclay
Frederique Motte, CEA/Saclay
Sean Carey, Spitzer Science Center
Robert Simon, University of Cologne
Eric Keto, CfA
Howard Smith, CfA
Lori Allen, CfA
Rob Gutermuth, CfA
Giovanni Fazio, CfA
Kathleen Kraemer, AFRL
Don Mizuno, AFRL
Stephan Price, AFRL
Joseph Adams, Cornell University

Science Category: star formation
Observing Modes: IracMap MipsScan
Hours Approved: 120.0

Abstract:
We propose a Spitzer Legacy Program to perform a uniform, unbiased survey of the Cygnus-X complex (~6x6 deg area) with IRAC and MIPS. This region contains the richest known concentration of massive protostars and the largest OB associations in the nearest 2 kpc. With this survey we can 1) analyze the evolution of high mass protostars with a large and statistically robust sample at a single distance, 2) study the role of clustering in high mass star formation, 3) study low mass star formation in a massive molecular cloud complex dominated by the energetics of ~100 O-stars, 4) assess what fraction of all young low mass stars in the nearest 2 kpc are forming in this one massive complex, and 5) provide an unbiased survey of the region and produce a legacy data set which can be used in conjunction with future studies of this region (e.g., with Herschel and JWST). The Cygnus-X survey will be an important step in constructing one of Spitzer's greatest legacies: surveying with high sensitivity and spatial resolution a representative sample of galactic star forming regions, from Bok globules to complexes containing millions of solar masses of gas and hundreds of O-stars.

Spitzer Space Telescope - General Observer Proposal #2361

The small scale structure of cluster forming Infrared Dark Clouds

Principal Investigator: James Jackson
Institution: Boston University, Institute for Astrophysical Res

Technical Contact: James Jackson, Boston University

Co-Investigators:
Jill Rathborne, Institute for Astrophysical Research, Boston Unive
Ronak Shah, Institute for Astrophysical Research, Boston Unive
Robert Simon, I.Physikal. Institut, Universitat zu Koln, Germany
Dan Clemens, Institute for Astrophysical Reseach, Boston Univer

Science Category: Star Formation
Observing Modes: MipsPhot
Hours Approved: 20.0

Abstract:
We propose to use the Spitzer Space Telescope to obtain 24micron MIPS raster maps toward 50 Infrared Dark Clouds (IRDCs), a new class of object recently identified as mid-infrared extinction features in the Galactic plane. We have identified ~12,000 IRDCs in the Galaxy, and using 13CO molecular line emission maps, have obtained reliable kinematic distances to ~300. We have selected the 50 darkest of these clouds for further study. Our molecular line and millimeter continuum data suggest that IRDCs are the cold molecular precursors to star clusters. They contain dense, cold cores with characteristic masses ~10 - 100 Msun. Thus, IRDCs have begun to fragment into pre-stellar cores, and may eventually form bound star clusters. Unlike previous MSX and ISO images, which suffered from spectral contamination from PAH emission features, the proposed 24 micron observations will cleanly identify the pre-stellar cores, provide reliable column density and mass estimates, independent of temperature, and combined with the millimeter and submillimeter images, allow us to separate the effects of column density and temperature variations for a large sample of IRDCs. Our goal is to understand the process of fragmentation in molecular clouds, the origin of the stellar initial mass function, and the origin of Galactic star clusters.

Spitzer Space Telescope - Archive Research Proposal #30120

Protostars in Infrared Dark Clouds

Principal Investigator: James Jackson
Institution: Boston U., Inst. for Astrophysical Research

Technical Contact: James Jackson, Boston University

Co-Investigators:
Jill Rathborne, Institute for Astrophysical Research
Edward Chambers, Institute for Astrophysical Research
Robert Simon, I. Physikalisches Institut

Science Category: star formation
Dollars Approved: 125771.0

Abstract:
We propose to use data from two Spitzer Space Telescope Legacy projects, GLIMPSE and MIPSGAL, to characterize a sample of compact cores within Infrared Dark Clouds (IRDCs), a new class of objects recently identified as mid-infrared extinction features in the Galactic plane. We have identified10,961 IRDCs in the Galaxy, and using 13CO molecular line emission maps, have obtained reliable kinematic distances to 312. Our molecular line and millimeter continuum data toward 38 IRDCs suggest that IRDCs are the cold molecular precursors to cluster-forming clumps. Each IRDC contains several dense, cold cores with characteristic masses of ~120 Msun. We find that 1/3 of these cores are sites of active star formation. In GLIMPSE images the active cores show extended 3-8 micron emission, with an apparent enhancement at 4.5 microns that might arise from shocked molecular hydrogen. Coincident with these active cores are bright, compact 24 micron point sources in MIPSGAL images. Follow-up molecular line observations of high-density tracing molecular lines confirm the star formation activity within several of these cores. Combining the GLIMPSE and MIPSGAL surveys with our catalog of IRDCs and their derived distances, we can identify and characterize a large sample of protostars within IRDCs across the Galaxy. Preliminary detection rates suggest that we will identify ~520 protostars of which we expect ~220 to be high-mass protostars. This study will increase the number of known high-mass protostars by at least an order of magnitude.

Spitzer Space Telescope - General Observer Proposal #30123

Active star formation in Infrared Dark Clouds

Principal Investigator: James Jackson
Institution: Boston U., Inst. for Astrophysical Research

Technical Contact: Jill Rathborne, Boston University

Co-Investigators:
Jill Rathborne, Institute for Astrophysical Research
Edward Chambers, Institute for Astrophysical Research
Robert Simon, I. Physikalisches Institut

Science Category: star formation
Observing Modes: IrsStare MipsSed
Hours Approved: 38.2

Abstract:
We propose to use the Spitzer Space Telescope to obtain MIPS SED and IRS observations toward a sample of compact cores within Infrared Dark Clouds (IRDCs), a new class of objects recently identified as mid-infrared extinction features in the Galactic plane. We have identified 10,961 IRDCs in the Galaxy, and using 13CO molecular line emission maps, have obtained reliable kinematic distances to 312. We have selected the 38 darkest of these clouds for further study. Our molecular line and millimeter continuum data suggest that IRDCs are the cold molecular precursors to cluster-forming clumps. Each IRDC contains several dense, cold compact cores with masses of 10-2,100 Msun. From IRAC images we find that 1/3 of these cores show extended, diffuse 3-8 micron emission, with an apparent enhancement in the 4.5 micron band. In addition, each of these cores is coincident with a bright 24 micron emission source in MIPS images and shows broad linewidths in high-density tracing molecular lines, suggesting they are sites of active star formation. Combined with mm/sub-mm data, the SEDs for these active cores reveal very large bolometric luminosities (~16,000 Lsun). Despite similar 1.2 mm fluxes, many cores show no 24 micron emission, suggesting that they are more quiescent. We request a total of 38.2 hours to obtain MIPS SED measurements of 80 IRDC cores and IRS 5-14 micron spectroscopy of 20 sources showing an enhancement at 4.5 microns. The 55-95 micron SEDs will establish accurate 24 micron to 1.2 mm SEDs, bolometric luminosities, masses, dust temperatures, and emissivity indices for the cores. The IRS spectroscopy will definitively distinguish whether the 4.5 micron enhancement arises from shocked molecular hydrogen, or whether it is due to an extincted continuum source.

Spitzer Space Telescope - Archive Research Proposal #40354

Protostars in Infrared Dark Clouds

Principal Investigator: James Jackson
Institution: Boston University

Technical Contact: James Jackson, Boston University

Co-Investigators:
Jill Rathborne, Harvard-Smithsonian Center for Astrophysics
Edward Chambers, Boston University
Irena Stojimirovic, Boston University

Science Category: star formation
Dollars Approved: 100000.0

Abstract:
Ample evidence suggests that Infrared Dark Clouds (IRDCs) host the very earliest stages of high-mass star formation and cluster formation. Our multiwavelength studies show that all IRDCs contain compact cores, and that about 1/3 of these cores show unambiguous signs of star-formation. In a previous archival proposal, we used the GLIMPSE survey to identify 444 active IRDC cores of known distance by finding slightly extended regions of enhanced 4.5 micron emission. We now propose to use MIPSGAL to directly detect the embedded protostars in these active cores via their 24 micron emission. Because the distances are known, we can estimate the luminosity of the embedded protostars and compare the derived luminosity function with standard initial mass functions. This project should increase the number of known high-mass protostars by at least an order of magnitude.

Spitzer Space Telescope - General Observer Proposal #50730

Deep Imaging of Cluster-forming IRDCs

Principal Investigator: James Jackson
Institution: Boston University, Institute for Astrophysical Res

Technical Contact: James Jackson, Boston University

Science Category: star formation
Observing Modes: IracMap MipsPhot
Hours Approved: 39.6

Abstract:
Ample observational evidence suggests that Infrared Dark Clouds (IRDCs) host the very earliest phases in the formation of both high-mass stars and star clusters. Our multi-wavelength studies show that all IRDCs contain compact cores, and that about 1/3 of these cores show unambiguous signs of star formation. These 'active' IRDC cores have slightly extended regions of enhanced 4.5 micron emission in GLIMPSE images. Bright, compact MIPSGAL 24 micron emission is also coincident with these active IRDC cores, indicating the presence of an embedded protostar. However, because of the limited sensitivity of the GLIMPSE and MIPSGAL surveys, these data only reveal the most massive protostars within the IRDCs and are insufficient to reveal any low- or intermediate-mass protostars that are expected within young clusters. While many IRDCs are sufficiently massive to form numerous protostars in a young cluster, their protostellar activity varies considerably. We now request Spitzer IRAC/MIPS time to achieve unprecedented sensitivity toward two massive IRDCs (one containing many protostars, the other containing few) in order to probe the fainter end of their embedded protostellar population. These data will reveal any lower-mass protostars that may exist within these IRDCs and, thus, reveal the mass distribution and evolutionary stage of the embeded cluster.

Spitzer Space Telescope - General Observer Proposal #50809

Testing Grain Surface Chemistry in Star Forming Regions

Principal Investigator: Jacqueline Keane
Institution: Institute for Astronomy, University of Hawaii

Technical Contact: Jacqueline Keane, IfA, University of Hawaii

Co-Investigators:
Adwin Boogert, IPAC

Science Category: star formation
Observing Modes: IrsStare
Hours Approved: 16.6

Abstract:
The key chemical reactions that produce the first generation ice mantles in dense molecular clouds are still poorly known. Within cold, dense clouds, species formed in the gas and on the grain surfaces will stick to the grains and form icy mantles. However, during star-formation, materials in the general cloud medium are subjected to numerous chemical and physical processes that are driven mostly by thermal and energetic radiation. The comparison between background stars and protostars is a proven excellent tool for this purpose. By comparing observed interstellar solid state abundances with models of grain surface chemistry it is possible to elucidate the efficiency and hence relevancy of a number of chemical reactions, in particular the CO$_2$ formation pathways. In part because of Spitzer, significant progress has been made towards understanding the various effects of these radiation processes on the ices around a large sample of high- and low-mass protostars. First results suggest that two different CO2 formation pathways play a role in these harsh environments. Though which reaction initially dominated the chemistry is unknown due to the numerous physical processes. Unfortunately, only a small sample of background field stars have been observed, most notably Taurus. In Taurus, only one reaction pathway appears to be efficient in quiescent regions, but this result is sample limited. We propose to take low resolution spectra from 5 to 22 microns along the line of sight toward 31 field stars behind the LDN 673 molecular cloud. Differences in near-IR ice chemistry have already been observed and we will use these mid-infrared data to provide more stringent constraints on chemical models of grain surface chemistry. With this sample it is possible to address fundamental questions in astrochemistry: what are the dominant grain surface chemistry pathways? What is the composition of the first generation ice mantles in molecular clouds?

Spitzer Space Telescope - Archive Research Proposal #50623

Bridging the gap: A Spitzer Census of Intermediate-Mass Star Forming Regions from Galactic Surveys.

Principal Investigator: Charles Kerton
Institution: Iowa State University

Technical Contact: Charles Kerton, Iowa State University

Co-Investigators:
Chip Kobulnicky, University of Wyoming

Science Category: star formation
Dollars Approved: 75000.0

Abstract:
High-mass star formation (M>10 Msun) appears to proceed through different channels than low-mass star formation (M<2 Msun). The differences between these two regimes are thought to include not only the timescales and masses involved but also the initial conditions and operative physics within the parent molecular clouds. We propose an archival analysis of ~50 *intermediate-mass* star formation (SF) regions that straddle the boundary between these two regimes---regions forming stars up to 4-8 Msun. These, relatively unknown and unstudied IR sources are selected by their IRAS colors and lie within the Spitzer GLIMPSE+MIPSGAL legacy survey fields. Compared to their more famous high-mass SF cousins (e.g., the Westerhout "W" HII objects), these regions are radio-quiet, relatively nearby, and structurally less complex. We will use complementary public-domain 13CO, 21-cm, and radio continuum Galactic surveys to 1) confirm the intermediate-mass SF nature of these objects, 2) compile a catalog and an atlas of mid-IR morphologies, 3) estimate distances, 4) calculate total luminosities and gas masses of affiliated molecular and atomic material, and 5) identify associated young stellar objects using IRAC+[24] colors. This work will provide a benchmark useful for contrasting the star formation process in both lower-mass and higher-mass SF environments.

Spitzer Space Telescope - General Observer Proposal #3121

Infrared Dark Clouds in the Inner Galaxy

Principal Investigator: Kathleen Kraemer
Institution: Air Force Research Laboratory

Technical Contact: Kathleen Kraemer, Air Force Research Laboratory

Co-Investigators:
Stephan Price, Air Force Research Laboratory
Sean Carey, SSC
Paul Feldman, National Research Council Canada
Michael Egan, Air Force Research Laboratory
Thomas Henning, Max Planck Institute for Astronomy
Russell Redman, National Research Council Canada
Russell Shipman, SRON
Marco Spaans, Kapteyn Astronomical Institute
Xander Tielens, SRON

Science Category: Star Formation
Observing Modes: IracMap IrsStare MipsPhot MipsSed
Hours Approved: 23.1

Abstract:
We propose to determine the physical properties of a recently discovered population of Galactic objects, infrared-dark clouds (IRDCs), with IRAC, IRS, and MIPS measurements by the Spitzer Space Telescope. IRDCs comprise a selection of cold, dense clouds with such high column densities that they appear in absorption against the Galactic IR background. They exhibit a variety of the earliest phases of star formation in clouds that are often massive enough to be the precursors of star clusters and OB associations. We propose to obtain small maps with IRAC and MIPS to determine how the spatial extent of the IRDCs and the sharpness of the cloud edge depend on wavelength, and what are the extinction characteristics of the clouds. We will obtain low spectral resolution data from IRS which will determine what emission (e.g., fine-structure lines, UIR features) and absorption (e.g., silicates, water) features are present and measure the UV penetration into the IRDCs. We will also use MIPS observations in the SED mode to determine the spectral energy distributions (SEDs) of the IRDCs. We will sample a variety of IRDC geometries, from globular to filamentary, as well as a small selection of near-infrared dark clouds and Bok globules to investigate the connection between infrared and optical dark clouds. These Spitzer data will enable us to determine the physical properties of this exciting class of objects and to place them in their proper context within the process of star formation.

Spitzer Space Telescope - General Observer Proposal #40511

A spectroscopic study of the giant infrared jet powering NGC 2264 G

Principal Investigator: Charles Lada
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Paula Stella Teixeira, Harvard-SAO

Co-Investigators:
Paula Stella Teixeira, Harvard-Smithsonian Center for Astrophysics
Carolyn McCoey, Dept. of Physics and Astronomy, Univeristy of Wate
Michel Fich, Dept. of Physics and Astronomy, University of Wate

Science Category: star formation
Observing Modes: IrsMap
Hours Approved: 20.0

Abstract:
We propose to obtain Spitzer IRS spectral maps of the jet associated with the NGC 2264 G outflow. Our analysis of Spitzer IRAC observations revealed the jet to continuously extend along the entire (~1 pc) length of the redshifted lobe of this very young and highly collimated CO outflow (Teixeira et al., 2007). We found the jet to undergo multiple changes in direction as a result of either precession or deflection. We intend to use the proposed IRS observations in conjunction with shock models to quantitatively evaluate how the physical conditions (temperature, column density, ionization) vary along the jet. In doing so we hope to test the hypothesis that the narrow jet we observed in the IRAC images has sufficient energy and momentum to both broaden and drive the molecular outflow. The second goal of this proposal is to obtain detailed mid-infrared diagnostics of the Class 0 driving source of the outflow, VLA2, and a nearby Class I source, VLA1 which is not driving an outflow. These two protostars have formed under similar conditions and their study will help us further understand how protostellar envelopes are modified by jets.

Spitzer Space Telescope - General Observer Proposal #50437

Highly excited OH in HH211 and other young protostellar outflows

Principal Investigator: Charles Lada
Institution: Harvard-Smithsonian Center for Astrophysics

Technical Contact: Charles Lada, Harvard-SAO

Co-Investigators:
Achim Tappe, Harvard-Smithonian Center for Astrophysics
John H. Black, Onsala Space Observatory, Chalmers University of T
August A. Muench, Harvard-Smithonian Center for Astrophysics

Science Category: star formation
Observing Modes: IrsMap
Hours Approved: 48.8

Abstract:
We have recently discovered extraordinarily high-J pure-rotational OH (v=0) emission in the young protostellar outflow HH211 as part of a Spitzer survey of protostars in the young cluster IC348. The high-res IRS spectrum shows an exceptionally rich sequence of high-J OH emission with a total number of 30 detected lines covering pure rotational transitions with upper levels J'=69/2 to 15/2. The highest excited transition has an upper state energy E/hc of almost 19,600cm^-1 (E/k about 28,000K) above the ground level. This is to our knowledge by far the highest rotational OH excitation observed to date. In addition, HH211 shows several pure rotational water transitions, H2 S(0) to S(7), HD R(3) to R(6), and atomic fine-structure lines from Fe+, Si+, Ne+, S, and Cl. This new discovery provides access to a new regime of density and temperature in a strong shock. For the first time, highly excited OH can be studied spatially resolved and in combination with H2, HD, H2O, and the complete range of atomic tracers in the Spitzer IRS range. Shock-driven chemistry models predict that OH primarily forms in a high temperature environment from endothermic reactions of atomic oxygen and H2, followed by further reaction with H2 to form water. This crucial reaction sequence forms two of the main coolants in molecular shocks, OH and H2O. The detection of highly excited OH provides a new probe to study the initiation of this sequence in the high excitation regions of interstellar shocks and a critical test for existing shock models. We therefore propose to survey a carefully selected sample of Herbig-Haro shocks and jets. Our primary aim is to find further examples of highly excited OH occurring together with H2O and H2 in protostellar outflows and to determine the physical conditions that lead to the formation of high-J OH. This will provide new insights into the high-temperature chemistry and the high observed OH/H2O abundances associated with interstellar shocks.

Spitzer Space Telescope - Archive Research Proposal #50732

Evolution of Star Formation in the Rosette Molecular Cloud

Principal Investigator: Elizabeth Lada
Institution: University of Florida

Technical Contact: Elizabeth Lada, University of Florida

Co-Investigators:
Jason Ybarra, University of Florida
Bruno Ferreira, University of Florida
Carlos Roman-Zuniga, Calar Alto Observatory
Zoltan Balog, University of Arizona
Nadya Gorlova, University of Florida

Science Category: star formation
Dollars Approved: 100000.0

Abstract:
We propose to combine the Spitzer archival IRAC and MIPS observations of the Rosette Molecular Cloud with our FLAMINGOS near-infared imaging and spectroscopic observations to study the star and planet forming activity in this cloud. Combining SPITZER and FLAMINGOS photometry and spectroscopy will allow us to create a complete census of the youngest stars in the cloud having masses slightly above the hydrogen burning limit. We will use the combined data base to determine the total numbers and spatial distribution of the young stars within the Rosette Molecular cloud and to determine the numbers and frequency distribution of protostars and sources with circumstellar disks. In particular we will use this information to investigate whether there is a temporal sequence of star formation in the Rosette Molecular cloud and whether there is any evidence for cluster evolution in the cloud, i.e. is the structure and distribution of the young sources related to their evolutionary state. Our combined Spitzer infrared imaging and FLAMINGOS spectroscopic survey will provide a more detailed picture of the numbers, masses, ages and locations of young embedded stars in the Rosette Molecular Cloud Complex than ever before and will provide and invaluable database for studies of star and cluster formation and early evolution.

Spitzer Space Telescope - Archive Research Proposal #20745

Digging faint young stellar objects in molecular clouds by comparing the YSO-poor SWIRE data and YSO-rich embedded young clusters

Principal Investigator: Shih-Ping Lai
Institution: University of Maryland

Technical Contact: Shih-Ping Lai, University of Maryland

Co-Investigators:
Lee Mundy, University of Maryland
Neal Evans, University of Texas
Lori Allen, Harvard-Smithsonian Center for Astrophysics
Paul Harvey, University of Texas
Nicholas Chapman, University of Maryland

Science Category: Star Formation
Dollars Approved: 21000.0

Abstract:
We propose to process the data of the SWIRE Legacy Project and seven selected embedded young clusters observed by GTO programs with the data reduction pipeline used by the c2d Legacy Project. The c2d Legacy Project aims to produce catalogs with large numbers of YSOs for an unbiased statistical study of stellar contents in the molecular clouds and statistical lifetime of YSOs at different evolutionary stages. To achieve this goal, it is essential to correctly identify YSOs and their evolutionary status.However, because of the high sensitivity of the Spitzer Space Telescope, the detected amount of background galaxies are not negligible in the molecular clouds observed by the c2d projects. Furthermore, galaxies and faint YSOs are virtually indistinguishable in the IRAC color-color diagrams and color-magnitude diagrams at the faint end. The analysis we propose will provide valuable information for the nature of YSOs and galaxies and the knowledge will be critical for complete understanding of the initial mass functions in the molecular clouds.

Spitzer Space Telescope - General Observer Proposal #30330

Chemical and Dynamical Evolution in L1251B

Principal Investigator: Jeong-Eun Lee
Institution: University of California, Los Angeles

Technical Contact: Adwin Boogert, AURA/NOAO-South

Co-Investigators:
Adwin Boogert, NOAO
Edwin Bergin, University of Michigan
Geoff Blake, California Institute of Technology
Anneila Sargent, California Institute of Technology
James Di Francesco, National Research Council of Canada
Neal Evans, University of Texas
Klaus Pontoppidan, California Institute of Technology

Science Category: star formation
Observing Modes: IrsMap
Hours Approved: 9.0

Abstract:
We propose to map the isolated nearby dense core L1251B, which includes a small group of protostellar objects, with IRS in modes SL1, SL2, SH, and LH, in order to study the chemical and dynamical conditions in this region. A wide variety of observations (including IRAC and MIPS observations) have been acquired toward L1251B, and these complimentary data set will be combined with the IRS spectra, which trace the composition of icy grain mantles and shocked material. We have a self-consistent model for the process of star formation, which couples the chemical evolution with the dynamics of surrounding material and the evolution of the central luminosity. The various ice features covered by the IRS spectra are vital to constrain the dust and chemical properties in our self-consistent model. In addition, the H2 pure rotational transitions and atomic lines such as Fe II, SI, and Si II, which will constrain the strength of shock(s) and the thermal processing of shocked material, will be also covered by the proposed IRS spectral mapping. Therefore, the obtained 5-37 micron spectral data cubes acquired by the proposed observations will enable three scientific goals: (1) to constrain self-consistently our chemical and dynamical evolutionary model, (2) to examine the spatial variation of ice components from the outer envelope to the inner hot region, and (3) study the effect of shocks on the quiescent material.

Spitzer Space Telescope - Archive Research Proposal #40857

A Wide-Field Low-Mass Census of the Nearest Star-Forming Region

Principal Investigator: Michael Liu
Institution: University of Hawaii

Technical Contact: Michael Liu, University of Hawaii

Co-Investigators:
Katelyn Allers, IfA/Hawaii
Eugene Magnier, IfA/Hawaii

Science Category: star formation
Dollars Approved: 76632.0

Abstract:
We propose to conduct a very wide-field census of young low-mass stars and brown dwarfs across the rho Ophiuchus cloud complex. Through a combination of archival c2d Spitzer Legacy data, the 2MASS all-sky catalog, and our own optical proper-motion imaging program, we will survey an area of 5 square degrees for young objects possessing circumstellar disks down to ~15 Mjup. Our selection methods have been proven to be exceptionally efficient, almost entirely free of the false positives (e.g. reddened background sources) that plague previous searches. Our census will represent more than an order of magnitude increase in area compared to past studies of this region and is uniquely capability of identifying the dispersed young population. For the resulting census of low-mass stars and brown dwarfs, we will examine (1) the spatial distribution, (2) the disk structural properties (flat versus flared), and (3) the kinematic properties. Our proposed study will allow, for the first time, an examination of low-mass disk properties over a range of host star mass, ages, local density, and extinction within a single star-forming cloud complex. Moreover, in light of the current active emphasis to push to the lowest possible substellar masses with deep pencil beam surveys, our proposed study will provide complementary insights into the star/brown dwarf formation process over a very large spatial scales (~10 pc). Finally, the resulting populous census of young low-mass objects will provide a rich sample for detailed follow-up with current and future telescopes.

Spitzer Space Telescope - General Observer Proposal #30645

MIPS SED Observations of Massive Quiescent Cores in Orion

Principal Investigator: Di Li
Institution: JPL/NASA

Technical Contact: Di Li, JPL/NASA

Co-Investigators:
Thangasamy Velusamy, JPL/Caltech
Paul Goldsmith, JPL/Caltech
Kenneth Marsh, JPL/Caltech

Science Category: star formation
Observing Modes: MipsSed
Hours Approved: 3.4

Abstract:
We propose to obtain MIPS SED data for a sample of 39 massive quiescent cores in Orion. Orion is the closest known massive star forming region and an ideal place for studying massive prestellar and protostellar cores. We have compiled a sample of Orion cores based on surveys at 350 and 450 microns and 1.2 mm. We have excluded cores within 4 pc of OB association and/or with IRAS point sources to avoid the destruction of prestellar cores by massive young stars. We have also obtained molecular spectroscopy data toward half of the sources. Our preliminary analysis shows that our core sample consists of structures more massive(mean mass ~ 10 solar mass) and generally warmer (~ 20 K) than low mass cores in Taurus. The density and temperature structure of the gas and dust envelopes of these quiescent cores provides important constraints for distinguishing between star formation models and determining the initial conditions of star formation. The Wien (shorter wavelength) side of dust continuum SED is more sensitive to temperature. Our existing data, however, are all on the Rayleigh-Jeans (longer wavelength) side.MIPS SED, from 50 to 100 microns, would provide both the intensity and the slope of the dust emission on the Wien side. Such information is crucial for deriving an accurate thermal structure, especially if a warm dust layer exists, which is likely for the cores in Orion. We are developing a 3d modeling algorithm (COREFIT) for modeling multiple wavelength dust continuum data with different beam sizes and PSFs. The proposed MIPS SED observations will be combined with existing data and analyzed using the COREFIT program. MIPS observations will enable us to achieve a good understanding of the dense core structure in massive star forming regions and derive an accurate mass for these cores.

Spitzer Space Telescope - General Observer Proposal #30859

An IRS Survey of Spitzer Identified Protostars in the Orion A Cloud

Principal Investigator: Tom Megeath
Institution: Ritter Observatory, University of Toledo

Technical Contact: Tom Megeath, Harvard, CfA

Co-Investigators:
Nuria Calvet, University of Michigan
Dan Watson, University of Rochester
Lee Hartmann, University of Michigan
Elise Furlan, UCLA
Lori Allen, SAO
James Muzerolle, University of Arizona

Science Category: star formation
Observing Modes: IrsStare
Hours Approved: 101.1

Abstract:
The Orion A Molecular Cloud is one of the richest regions of star formation in the nearest kiloparsec.This 30 parsec long filament shows a remarkable gradient in star formation properties, from the rich cluster of low and high mass stars in the Orion Nebula, to the the small groups and isolated stars in Orion South. This gradient in star formation properties is correlated with changes in properties of the dense gas, specifically the gas kinetic temperature, turbulence, and column density. Using IRAC/MIPS onboard Spitzer, we have surveyed this cloud, and have identified a population of almost 300 probable protostars. We propose to observe 183 of these sources with the IRS, to obtain low resolution 5-36 micron spectra. Combining these spectra with photometry from IRAC, MIPS and sub-millimeter telescopes, we will constrain the properties of these protostars. We will search for variations in basic protostar properties, such as the mass accretion rate and rotation rate, to determine whether the properties of the protostars also change with cloud position. With this analysis, we hope to correlate the properties of the protostars with that of the gas - providing, perhaps, the first empirical determination of how the conditions of the dense gas influence the properties of the incipient stars.

Spitzer Space Telescope - General Observer Proposal #50374

An IRS Survey of Spitzer Identified Protostars in the Orion Molecular Clouds

Principal Investigator: Tom Megeath
Institution: Ritter Observatory, University of Toledo

Technical Contact: Tom Megeath, Ritter Observatory, University of Toledo

Co-Investigators:
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Dan Watson, University of Rochester
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Elise Furlan, UCLA
Lori Allen, SAO
James Muzerolle, University of Arizona

Science Category: star formation
Observing Modes: IrsStare
Hours Approved: 36.6

Abstract:
Understanding protostellar evolution is a necessary step toward characterizing the factors which ultimately determine the properties of emerging stars and their planetary systems. We propose the completion of a Spitzer IRS survey of 362 protostars in Orion; thus providing a unique sample selected in an unbiased manner from their 24~mum fluxes and spectral energy distribution slopes. This is the richest known sample of protostars at a common distance within 450 pc of the Sun. The low resolution IRS 5-36~mum spectra, in concert with existing Spitzer imaging, existing ground-based near-IR data, and future Herschel GTO and proposed Open Time observations will be used to determine the fundamental properties of the protostellar envelopes and disks (properties such as envelope structure, density and angular momentum, disk luminosity). The Orion molecular cloud complex contains an exceptionally wide range of parental gas conditions (i.e. initial conditions) and environments (from dense clusters to relatively isolated protostars). By comparing the properties of protostars in different regions of Orion clouds; we will assess the roles of initial conditions, environment and feedback from outflows in guiding protostellar evolution. These observations will produce a unique legacy dataset for guiding and testing a theory of protostellar evolution.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #113

Emission lines from shocks: water, molecular hydrogen, and low-excitation ions in the Cep A East and HH 7-11 outflows

Principal Investigator: Gary Melnick
Institution: Harvard-Smithsonian Center for Astrophysics

Technical Contact: Dan Watson, University of Rochester

Science Category: Star Formation
Observing Modes: IrsMap
Hours Approved: 11.4

Abstract:
Emission lines from shocks: water, molecular hydrogen, and low-excitation ions in the Cep A East and HH 7-11 outflows PI: Gary Melnick, Center for Astrophysics Co-Is: Ted Bergin, Center for Astrophysics David Neufeld, Johns Hopkins U. Dan Watson, U. Rochester SIRTF and the IRS offer access, at moderate spectral and spatial resolution, to some of the best molecular and atomic probes of the outflows and shocks associated with recent star formation. Here we intend to use IRS for emission-line imaging of Cepheus A East and HH 7-11, two well-known star-formation regions that were studied in detail by SWAS. The maps we obtain will include extended emission by molecular hydrogen (v = 0 S(0)-S(5)) and water (several pure rotational lines), as well as numerous transitions of low-excitation atomic and ionic species associated with jets and shocks. We will use these data, combined with SWAS observations of thermal water-line emission and shorter-wavelength H2 and [Fe II] images, in models of the excitation, energetics and chemistry of the shocked gas.

Spitzer Space Telescope - General Observer Proposal #30955

Completing the Mapping of the W3 Giant Molecular Cloud; Testing Models and the Importance of Triggered Star Formation

Principal Investigator: Toby Moore
Institution: Liverpool John Moores University

Technical Contact: Toby Moore, Liverpool John Moores University

Co-Investigators:
James Allsopp, Liverpool John Moores University
Huw Jones, Liverpool John Moores University

Science Category: star formation
Observing Modes: IracMap MipsScan
Hours Approved: 7.0

Abstract:
It is proposed to complete the R. Gehrz's mapping of W3 at both IRAC and MIPS 24um wavelengths. W3 is an outer galaxy Giant Molecular Cloud comprising of two regions; a quiescent, spontaneously star forming region and a region compressed by the W4 OB association containing the majority of star formation and all of the high mass star formation. Currently only the high-density region, Lada(put date) is mapped, but for a scientifically-valid comparision between the triggered and spontaneous modes we require the remainder of the cloud to be mapped. Triggered star formation is vitally important as it provides a mechanism for understanding the massive disparity between the low star formation efficiencies of galaxies such as our own andmore violent events such as galaxy mergers. Currently we have mapped the majority of the cloud at 850 um using SCUBA and the whole cloud using the CO(J=1-0) with the 12CO, 13CO and C18O isotomers. From these studies we have identified and measured the masses of 230 clumps. Without Spitzer data we have no way of determining which of these clumps have formed stars. This project forms the final crucial piece which when added to our current observations of the mass in the cloud will quantify the local star formation efficiency for each region. This is the first part of an ongoing much larger study into triggered star formation. We used Aztec (1.1mm continuum) on the JCMT in January 2006 to map two more clouds and Spitzer data on these from other observers has either been recently released or is about to be. In 2007, we will expand on the knowledge gained from this with the SCUBA2 JCMT Galactic Plane Survey (JPS) in which we are collaborators.

Spitzer Space Telescope - Archive Research Proposal #40008

Constraints on the stellar initial mass function from Spitzer

Principal Investigator: August Muench
Institution: Smithsonian Astrophysical Observatory

Technical Contact: August Muench, Smithsonian Astrophysical Observatory

Co-Investigators:
Kevin Luhman, The Pennsylvania State University

Science Category: star formation
Dollars Approved: 106363.0

Abstract:
The stellar initial mass function (IMF) is a fundamental quantity in astrophysics and a valuable probe of the process of star formation. While there are many theories committed to deducing the origin of the IMF, there is also a dearth of good IMF constraints in star forming regions and a limited range of physical environments for which IMFs have been derived. We propose to use the Spitzer archive to rectify this problem by deriving IMF constraints in star forming regions over the local 1 kpc. We will construct and analyze 3 micron luminosity functions for embedded clusters that are located in five different star forming regions and that contain a range of most massive member stars. We will use our existing luminosity function modeling code to constrain the basic IMF parameters, e.g., the peak or characteristic mass formed in a star forming region and correlate these quantities to physical environmental parameters such as the presence of O type stars and the stellar surface density in each cluster. The very large mosaics provided by the Spitzer archive will also allow us to search for spatial variations of the IMF within a star cluster, variations that we have documented using both luminosity function modeling and spectroscopic followup.

Spitzer Space Telescope - General Observer Proposal #50364

Probing jets from Class 0 protostars

Principal Investigator: Brunella Nisini
Institution: INAF-Osservatorio Astronomico di Roma

Technical Contact: Brunella Nisini, INAF-Osservatorio Astronomico di Roma

Co-Investigators:
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Odysseas Dionatos, INAF-Osservatorio Astronomico di Roma, Italy
Teresa Giannini, INAF-Osservatorio Astronomico di Roma, Italy
Tom P. Ray, Dublin Institute for Advanced Studies, Ireland
Michael D. Smith, CAPS, University of Kent, UK

Science Category: star formation
Observing Modes: IrsStare
Hours Approved: 22.3

Abstract:
Flows of matter from young and heavily embedded ‘‘Class 0’’ protostars are often observed only at millimeter wavelengths in the form of collimated molecular jets. An important open debate is whether such jets represent the cold external layer of an embedded atomic jet, or whether the jet itself is intrinsically composed of only molecular gas under low excitation conditions. The aim of this proposal is to obtain insight into the composition and excitation of such jets through IRS observations of mid-IR lines, which are unique tracers of the warm embedded gas components. The immediate objectives will be: 1) to detect the atomic/ionic component associated with Class 0 molecular jets; 2) to derive detailed physical quantities to be compared with models for acceleration and propagation of jets, models which have so far only been tested on more evolved CTT stars; 3) to determine if such jets have sufficient momentum and energy to sustain the swept up gas seen further out in the form of near-IR bow shocks. To this aim, a sample of three well-known Class 0 jets have been selected for which near-IR, millimeter and ISO observations are already available. This will ensure a thorough comparison of the different jet excitation components which should ultimately be explained in a unified flow model. The feasibility of this project and the original results that can be obtained by such a project have been demonstrated on one source observed during cycle-2 GO. Here we wish to extend such a study on additional sources in order to derive general conclusions.

Spitzer Space Telescope - Legacy General Observer Proposal #30816

Taurus 2: Finishing the Spitzer Map of the Taurus Molecular Clouds

Principal Investigator: Deborah Padgett
Institution: California Institute of Technology

Technical Contact: Deborah Padgett, California Institute of Technology

Co-Investigators:
Sean Carey, Spitzer Science Center
Alberto Noreiga-Crespo, Spitzer Science Center
Misato Fukagawa, Nagoya University
Luisa Rebull, Spitzer Science Center
Karl Stapelfeldt, Jet Propulsion Laboratory
Manuel Guedel, University of Zurich
Francois Menard, Observertoire de Grenoble
Marc Audard, Columbia University
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Tim Brooke, Caltech
Tracy Huard, SAO
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Catherine Dougados, Observatoire de Grenoble
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Bill Latter, Spitzer Science Center
Jerome Bouvier, Observatoire de Grenoble
Nicolas Grosso, Observatoire de Grenoble
David Shupe, Spitzer Science Center
Steve Skinner, CASA
Caer-Eve McCabe, Jet Propulsion Laboratory

Science Category: star formation
Observing Modes: IracMap MipsScan
Hours Approved: 60.0

Abstract:
The star-forming clouds nearest to our Sun are located 140 pc away in Taurus. Lacking young stellar clusters and luminous OB stars, Taurus hosts a distributed mode of star formation that has proven particularly amenable to observational and theoretical study. Last year, our team mapped the central 30 square degrees of the main Taurus cloud. A new, high resolution CO map of the region by Goldsmith et al. (2005) shows that Spitzer has not yet mapped the western portion of the cloud which contains interesting star formation activity. In addition, changes made to GTO program 6 last year have resulted in insufficient coverage of the important L1495 and L1536 clouds. We propose to complete our comprehensive, unbiased and spatially contiguous map of the TMC using MIPS and IRAC, adding an area of 24 square degrees and restoring full coverage of L1495 and L1536. Achieving sensitivities 20 times better than ISOCAM at 8 microns, and 200 times better than IRAS at 24 microns, these maps will reveal the lowest luminosity members of the young stellar population in western Taurus: collapsing protostars, young substellar objects, and edge-on disks. Due to the importance of this dataset for the star formation community, we request that our program be granted Legacy status. As with our previous GO1 program, our team will waive our proprietary rights to the data and make the images and source catalogs from the entire Spitzer Taurus survey available to the community in 2006 and 2007. This survey is a central and crucial part of a multiwavelength study of the Taurus cloud complex that we have performed using XMM, and CFHT. The seven photometry data points we will obtain from Spitzer will allow us to characterize the circumstellar environment of each object, and, in conjunction with NIR photometry, construct a complete luminosity function for the cloud members that will place constraints on the initial mass function.

Spitzer Space Telescope - General Observer Proposal #20403

A Fresh Look at Distributed vs. Clustered Star Formation: IRAC and MIPS Imaging of the Cep OB3 and Mon R2 Molecular Clouds

Principal Investigator: Judy Pipher
Institution: University of Rochester

Technical Contact: Judy Pipher, University of Rochester

Co-Investigators:
S Thomas Megeath, Harvard Smithsonian, CfA
Lori Allen, Harvard Smithsonian, CfA
Philip Myers, Harvard Smithsonian, CfA
Robert Gutermuth, University of Rochester
James Muzerolle, University of Arizona

Science Category: Star Formation
Observing Modes: IracMap MipsScan
Hours Approved: 82.5

Abstract:
We propose an IRAC+MIPS survey toward two giant molecular clouds containing massive star forming regions, Cep OB3 and Mon R2. We have already obtained GTO observations of the young clusters in these clouds: in this program we will map the remainder of each molecular cloud, with the goal of locating the isolated protostars and stars with disks via their mid-IR excesses. The selected giant molecular clouds house multiple clusters of relatively high mass star formation, and will complement the C2D legacy program maps of nearby molecular clouds containing predominately low mass star formation. These data will enable a fresh look at the importance of distributed star formation and will provide a unique opportunity to test whether the vast majority of star formation actually occurs in clusters, the current paradigm, or whether distributed star formation plays a major role. Spitzer provides the unique capabilities of high sensitivity at wavelengths where extinction is low, plus the ability to easily identify IR excess emission around stars and brown dwarfs. Spitzer is the only such facility to enable wide-field studies of the distributed population of IR excess objects now, and for well into the future.

Spitzer Space Telescope - General Observer Proposal #20015

IRAC and MIPS Observations of the North American and Pelican Nebulae

Principal Investigator: Luisa Rebull
Institution: SSC

Technical Contact: Luisa Rebull, SSC

Co-Investigators:
Sean Carey, SSC
John Carpenter, Caltech
David Cole, JPL
Lynne Hillenbrand, Caltech
Deborah Padgett, SSC
John Stauffer, SSC
Karl Stapefeldt, JPL
Stephen Strom, NOAO

Science Category: Star Formation
Observing Modes: IracMap MipsScan
Hours Approved: 49.3

Abstract:
The most extensively studied star-forming regions are Taurus, Ophiuchus and the Chamaeleon complex (low density, no O and B stars) and Orion (high density, concentrated O and B stars). These regions have served as our primary empirical guide to understanding the formation and early evolution of stars and their associated accretion disks. However, these nearby cloud complexes provide snapshots of just the extrema of the star-formation process. Because environment (e.g., radiation field, stellar density) appears to play a significant role in defining, e.g., accretion disk lifetimes and outcome stellar mass functions, it is essential to sample a much broader range of the star-forming environmental spectrum. The nearby (600 pc) North American and Pelican Nebulae Complex (NAN) is such a region. The giant molecular cloud (GMC) housing the NAN contains both an extensive (>10^4 stars) distributed young (1-5 Myr) low and high mass population spanning 2x2 degrees (30x30 pc), as well as newly-formed stars in multiple clusters and aggregates. Despite the proximity of the complex and its rich population of distributed and clustered stars spanning a range of masses, there are as yet NO significant Spitzer data for the NAN. We propose to carry out a deep IRAC and MIPS survey of a ~4 square degree region covering the NAN complex with the goals of (a) mapping the pattern of star forming activity in a region intermediate in environmental characteristics between Orion and Taurus, and linking this pattern to the extensive molecular line studies of this GMC; (b) determining accretion disk lifetimes and characterizing the early evolution of debris disks for a statistically robust sample of young stars spanning a wide range of masses. Because we believe that surveying of this, the 3rd nearest high-mass star-forming GMC, will provide a rich legacy database both for our team and the star-formation community, we waive proprietary rights to our MIPS and IRAC maps.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #53

Pre-stellar and Proto-stellar Cores and Cold Dust

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: Jocelyn Keene, JPL

Science Category: Star Formation
Observing Modes: MipsPhot MipsScan
Hours Approved: 34.5

Abstract:
This proposal is designed to address several different scientific topics, the unifying theme of which is the search for and observation of nearby, very cold, dusty sources. We plan an imaging survey of pre-stellar cores to search for lower luminosity and/or younger sources than have been found in the IRAS and ISO data. Recent comparisons of pre-stellar and proto-stellar cores have indicated that they have fundamentally different structures: pre-stellar cores have not yet developed steep density gradients near their centers. These results were inferred from sub-millimeter observations of flux gradients in pre- and proto-stellar cores. MIPS has the capability for not only measuring flux gradients, but also temperature gradients and thus measuring much more directly the density gradients of the young cores to see whether this conclusion holds up. We plan an SED survey of some proto-stellar and pre-stellar cores to measure temperature and density gradients. Finally, MIPS is ideally suited to mapping far-infrared color temperatures, which we propose to do in a small number of clouds that have been well studied in the near-infrared and at other wavelengths. These data can be used to study the grain properties in the clouds.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40196

Methanol Masers in the Galactic Center

Principal Investigator: George Rieke
Institution: University of Arizona

Technical Contact: Joannah Hinz, University of Arizona

Co-Investigators:
Farhad Yusef-Zadeh, Northwestern University

Science Category: star formation
Observing Modes: MipsPhot
Hours Approved: 0.8

Abstract:
We request less than one hour of time with the MIPS instrument at 70um to examine the sites of massive star formation in the nuclear region of the Galaxy, as probed by methanol masers, to get a better insight in the process of star formation in this complex region. This important region of the Galaxy hosts several sources of energetic activity as well as the site of massive molecular clouds with pockets of on-going and past massive star formation. The spectral energy distributions of the maser sources will allow us to identify the census of on-going massive and intermediate massive star-forming regions in the nuclear disk and compare them with nearby sites of massive star formation. This is a pointed follow-up proposal to a large scan map of the Galactic Center recently produced by MIPS.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #22

Observations of nine-micron IRTS sources

Principal Investigator: Thomas Roellig
Institution: NASA Ames Research Center

Technical Contact: Thomas Roellig, NASA Ames Research Center

Science Category: Star Formation
Observing Modes: IracMap IrsStare
Hours Approved: 24.3

Abstract:
During the course of its one month mission, the Infared Telescope in Space detected a number of unusal objects with strong nine-micron peaks. This investigation follows up these discoveries. The program consists of IRAC mapping followed up by IRS low-resolution spectroscopy of candidate objects detected in the IRAC survey.

Spitzer Space Telescope - General Observer Proposal #30534

IRS observations of extremely young (high mass) stars in the NGC7538 S cloud core

Principal Investigator: Goran Sandell
Institution: USRA

Technical Contact: Goran Sandell, USRA

Science Category: star formation
Observing Modes: IrsMap IrsPeakupImage IrsStare
Hours Approved: 3.4

Abstract:
The molecular cloud SW of NGC7538 is a well studied high-mass star forming region, although the third star froming core, NGC7538 S has received very little attention since the seminal work by Werner et al in 1979. Recently Sandell et al discovered a high mass protostar with a rotating disk in this massive cold cloud core. Preliminary analysis of IRAC archive data show that this high-mass star is detected by IRAC at wavelengths longer than 4.5 micron and show a small cluster of deeply embedded young stars about 10" to the NW of the star. In this proposal we plan to use IRS to measure the SED of this unique high-mass protostar, because the broadband IRAC data appear to be heavily affected by absorption bands from the dense, cold surrounding cloud core. We will also obtain spectra of all the stars in the embedded cluster to bettert understand their evolutionary status. We have identified four H2O masers coinciding with IRAS sources in the southern part of the cloud and we will also take low resolution spectra of these sources. Finally we ask for modest support to continue analysing the IRAC data of NGC7538 to support and complement the IRS project, our extensive BIMA and VLA observations of this region and aid in planning future observation with CARMA as soon as it becomes operational.

Spitzer Space Telescope - General Observer Proposal #20220

High Resolution IRS Mapping of the Star-Forming Region NGC 6334 A

Principal Investigator: Anuj Sarma
Institution: DePaul University

Technical Contact: Anuj Sarma, DePaul University

Co-Investigators:
Nicholas Abel, University of Kentucky
Elizabeth Mayo, University of Kentucky
Gary Ferland, University of Kentucky
Thomas Troland, University of Kentucky

Science Category: Star Formation
Observing Modes: IrsMap
Hours Approved: 7.5

Abstract:
Star formation involves the interplay of thermal, gravitational and magnetic forces. These processes lead to a dynamically evolving region in which O stars ionize the surrounding medium, and the ionized gas expands into the molecular cloud. Of these forces, magnetic effects are the least understood. A detailed analysis of the conditions in star-forming environments requires that one combine magnetic field observations with observations of the ionized, atomic, and molecular gas along with dust. We propose to carry out high-resolution IRS spectroscopy between 9.9-37.2 microns of the nearby (1.7 kpc) star-forming region NGC 6334 A. Maps of the magnetic field strength in the molecular gas exist for NGC 6334 A, yet the conditions in the H II region, the surrounding photodissociated region (PDR), and the dynamical interaction between the two regions are poorly understood. In the H II region, our proposed observation will allow us to use well-known infrared diagnostic ratios to determine the electron density, temperature, and the hardness of the continuum source. Spitzer observations of rotational transitions of molecular hydrogen and PAH emission, combined with previous observations, will allow us to determine the hydrogen density, UV radiation flux, and temperature in the PDR. We will combine our observations with theoretical calculations, using the spectral synthesis code Cloudy. Recent improvements to Cloudy include a ~1000 reaction molecular network, the ability to treat the dynamical flow of ionized gas into a molecular cloud, and the effects of magnetic pressure. Matching the observed spectra with theoretical calculations will tell us the physical conditions in the H II region and PDR, the role of magnetic fields in NGC 6334 A, and the importance of dynamics in the region. Overall, IRS observations of NGC 6334 A offers a unique opportunity to study, at high spatial resolution, many of the physical processes in star-forming regions.

Spitzer Space Telescope - General Observer Proposal #50291

G333.2-0.4: Star Formation in a Turbulent Giant Molecular Cloud

Principal Investigator: Janet Simpson
Institution: NASA Ames Research Center

Technical Contact: Janet Simpson, NASA Ames Research Center

Co-Investigators:
Angela Cotera, SETI Institute
Michael Burton, University of New South Wales
Maria Cunningham, University of New South Wales
Indra Bains, Swinburne University
Nadia Lo, University of New South Wales

Science Category: star formation
Observing Modes: IrsMap
Hours Approved: 19.3

Abstract:
Most stars form in clusters of 100 or more members, in the vicinity of OB stars, and in very different conditions from those assumed by standard ambipolar diffusion models. The effect that the feedback from the OB stars has on the nearby gas is not known: it may trigger new stars, or it may disrupt the gas, preventing further star formation. Models disagree on the likely effects, but some testable predictions have been made, such that only low and medium mass stars may form in these conditions, and that injection of energy from protostellar flows at small scales is necessary to sustain star formation in a region. Recently it has been suggested that supersonic interstellar turbulence is critical for promoting the density enhancements needed to form stars and for preventing large scale collapse of giant molecular clouds (GMCs) into stars. As a result stars could form even in the envelopes of the GMCs at significant distances from the OB star clusters. Our group is studying the G333.2-0.4 GMC, both through radio observations of the molecular lines (from which we derive the density, temperature, velocity, and turbulence structures) and through analysis of the Spitzer GLIMPSE and MIPSGAL and 2MASS images (from which we determine the stellar population parameters). We have found 12 objects in the IRAC images that have the appearance of young stellar objects (YSOs), all lying at some distance from the central OB star clusters. Six objects almost surely have molecular hydrogen outflows from their IRAC 4.5 micron images and six are extremely red and probably quite luminous. We propose IRS spectral observations of these candidate YSOs, plus one molecular outflow source, to determine the spectral types and ages of the objects and their outflow characteristics. These observations will allow us to link the stellar and protostellar content to the turbulent properties of the molecular gas determined from the G333 multi-molecular line survey of the region.

Spitzer Space Telescope - General Observer Proposal #30848

MIPSCAR: A Far-Infrared Survey of the Carina Nebula

Principal Investigator: Nathan Smith
Institution: University of Colorado

Technical Contact: Nathan Smith, University of Colorado

Co-Investigators:
Sean Carey, Spitzer Science Center
Barbara Whitney, Space Science Institute
Edward Churchwell, University of Wisconsin
Keivan Stassun, Vanderbilt University

Science Category: star formation
Observing Modes: MipsScan
Hours Approved: 24.7

Abstract:
The Carina Nebula provides a unique laboratory in which to study an environment where very massive stars are influencing the birth and early evolution of low-mass stars and protoplanetary disks in their immediate environment. What makes it unique is the combination of its rich stellar content and its proximity -- it is close enough to spatially resolve protoplanetary disks and Herbig-Haro jets, and to detect young pre-main sequence stars down to the hydrogen burning limit, while containing an extreme stellar population comparable to some of the most massive clusters in our Galaxy or 30 Doradus. We propose to map several square degrees of the Carina Nebula at 24 and 70 microns with MIPS. Combined with a large existing dataset that includes previous Spitzer/IRAC and HST imaging plus extensive ground-based data, far-IR MIPS imaging will reveal the complete distribution of embedded star forming cores in the region, and will allow us to measure the bolometric luminosities of embedded clusters and the driving sources of HH jets. MIPS 24 micron photometry adds a particularly critical lever arm to existing 1-8 micron spectral energy distributions, which will break the degeneracy in model fits and derived properties (masses, luminosities, disk masses, accretion rates, etc.) of young stars throughout the region.

Spitzer Space Telescope - Directors Discretionary Time Proposal #266

Young Stars in IC 2118

Principal Investigator: Tim Spuck
Institution: Oil City Area Sr. High School

Technical Contact: Luisa Rebull, SSC

Co-Investigators:
Babs Sepulveda, Lincoln High School
Tony Maranto, Phillips Exeter Academy
Cynthia Weehler, Luther Burbank High School
Theresa Roelofsen, Bassick High School
Luisa Rebull, Spitzer Science Center

Science Category: Star Formation
Observing Modes: IracMap
Hours Approved: 11.6

Abstract:
IC 2118, the Witch Head Nebula (~210 parsecs), is a region of star formation located near the supergiant star Rigel in the constellation Orion. Last year, we observed the head of the nebula and approximately QUADRUPLED the number of young stars known here. We propose using IRAC and MIPS to continue our investigation by observing the densest part of the rest of the cloud. Our team proposes to use IRAC and MIPS observations to (1) investigate star formation, (2) look for likely cluster member stars with infrared excesses, and characterize this young star population by obtaining their colors and therefore estimates of masses and ages, (3) study the distribution of stars, their relationship to the ISM, and the possibilities of triggered star formation, (4) compare the young star population, distribution, and age to other similar sites of star formation, e.g., IC 1396 and (5) produce a dramatic image of the interstellar medium in the region surrounding IC 2118. Since this region is in the Orion constellation near the bright star Rigel, it provides additional appeal to students and the general public.

Spitzer Space Telescope - Directors Discretionary Time Proposal #480

Star formation in Lynds dark clouds

Principal Investigator: Tim Spuck
Institution: Oil City Area Sr. High School

Technical Contact: Luisa Rebull, SSC

Co-Investigators:
Luisa Rebull, SSC

Science Category: star formation
Observing Modes: IracMap MipsPhot
Hours Approved: 1.2

Abstract:
Recent research on star formation in large molecular cloud complexes, such as the Cepheus Flare (Kun 1995), Orion, Perseus (Rebull et al. 2007), and Taurus molecular clouds, have included studies of a number of Lynds dark nebulae (LDN). Less attention has been given to isolated Lynds clouds. Both LDN 981 and LDN 425 are smaller, more isolated, dark molecular clouds that could contain regions of active star formation within them -- they both are associated with IRAS sources, and based on prior shallow surveys, they both have a YSO candidate in the neigborhood. Spitzer observations with IRAC and MIPS will allow us to see deep inside the cloud, deeper than any prior observations could see, and reveal any hidden star formation that is ongoing in these clouds. This project is part of the Spitzer Teachers Program.

Spitzer Space Telescope - General Observer Proposal #40503

The first brown-dwarf eclipsing binary: Fundamental tests of brown-dwarf formation and evolution

Principal Investigator: Keivan Stassun
Institution: Vanderbilt University

Technical Contact: Keivan Stassun, Vanderbilt University

Co-Investigators:
Subhanjoy Mohanty, Harvard-Smithsonian Center for Astrophysics
Robert Mathieu, University of Wisconsin - Madison

Science Category: star formation
Observing Modes: IracMap IrsPeakupImage MipsPhot
Hours Approved: 2.4

Abstract:
We propose a small and straightforward GO program, requiring only 2.4 hr of Spitzer time, to fully characterize the only known empirical benchmark of the fundamental physical properties of young brown dwarfs. 2M0535-05, a newly discovered eclipsing binary in the Orion Nebula consisting of two brown dwarfs, is a crucial system for study because it provides the first---and to date only---direct and accurate measurements of masses and radii for newly formed (~1 Myr) brown dwarfs. Here we seek to: (a) characterize the presence of any protoplanetary disk material in this system in order to study the evolution of such disks in young brown dwarfs; and (b) empirically determine the brown dwarfs' spectral energy distributions in order to stringently test the predictions of theoretical brown-dwarf evolutionary models. With these aims, we will combine IRAC, PCRS, and MIPS observations with Gemini observations in the optical and 2MASS measurements in the near-infrared, in order to fully characterize and model the photospheric and disk components of the spectral energy distribution of 2M0535-05 from 0.5 to 24 um. The observations proposed here are necessary to realize the full potential of 2M0535-05 as a fundamental benchmark in our understanding of the nature and origins of brown dwarfs.

Spitzer Space Telescope - General Observer Proposal #20339

The Lambda Ori Star-Forming Region as a Laboratory for Constraining Environmental Influences on Circumstellar Disk Lifetimes

Principal Investigator: John Stauffer
Institution: Spitzer Science Center

Technical Contact: Luisa Rebull, SSC

Co-Investigators:
David Barrado y Navascues, LAEFF, Spain
Luisa Rebull, SSC
Lee Hartmann, CfA
Solange Ramirez, SSC
Tom Megeath, SAO
Lori Allen, SAO

Science Category: Star Formation
Observing Modes: IracMap MipsScan
Hours Approved: 27.9

Abstract:
We propose to examine in detail a single, particularly diverse star-forming region, the Lambda Ori star-forming region (LOSFR), with the goal of attempting to understand how the local environment may affect disk formation and evolution even within a single star-forming region. At the center of the LOSFR is a compact, rich cluster containing many high mass stars and thought to have been the site of a supernova within the past approximately two million years. Winds from the supernova and the remaining high mass stars have clearly sculpted the ISM over the 15 x 15 pc region of the LOSFR, sweeping up most of the gas and dust into a shell seen prominently with IRAS. A number of additional clusters exist in the LOSFR, many of them near the ‘‘leading edge" of the molecular gas in the ring, possibly indicating that star formation at those sites was triggered by the shock wave associated with the events occurring in the central star cluster. We have previously obtained Spitzer IRAC and MIPS imaging of the central star cluster with the aim of determining the frequency of circumstellar disks there. With this proposal, we ask for additional time to obtain maps of several other sites of recent star-formation in the LOSFR in order to determine the IMF of these clusters and their disk frequency and radial structure as a function of cluster age and cluster location within the LOSFR. We will use these data, along with ground-based photometry and spectroscopy which we are gathering, in order to form a more detailed model of the star-forming history of the LOSFR.

Spitzer Space Telescope - General Observer Proposal #20762

Using Spitzer IRAC Imaging As A Solid Foundation For A Comprehensive Study Of The Molecular Core L1551-MC.

Principal Investigator: Jonathan Swift
Institution: University of California, Berkeley

Technical Contact: Jonathan Swift, Institute for Astronomy

Co-Investigators:
Wm. Welch, University of California, Berkeley
James Di Francesco, National Research Council of Canada, HIA

Science Category: Star Formation
Observing Modes: IracMap
Hours Approved: 0.3

Abstract:
We propose to observe the newly discovered pre-protostellar core, L1551-MC, in search of a deeply embedded protostar. All previous observations of this region spanning wavelengths from cm to the near IR have failed to reveal direct evidence for such an object. However, the existence of the Herbig-Haro object HH265 in close proximity to the core and spectral signatures seen in our recent molecular line maps are suggestive of protostellar activity. The Spitzer Space Telescope has the sensitivity and resolution to unambiguously identify any embedded protostellar source providing a solid reference point for the continuing thesis work on this object.

Spitzer Space Telescope - General Observer Proposal #50039

Spitzer observations of DC 314.8-5.1: Dust properties and star formation in an isolated globule

Principal Investigator: Douglas Whittet
Institution: Rensselaer Polytechnic Institute

Technical Contact: Douglas Whittet, Rensselaer Polytechnic Institute

Co-Investigators:
Sachindev Shenoy, Spitzer Science Center
Amanda Cook, Rensselaer Polytechnic Institute

Science Category: star formation
Observing Modes: IracMap IrsMap IrsStare MipsPhot
Hours Approved: 9.3

Abstract:
There is much current interest in identifying dense cores and globules prior to or close to the onset of low-mass star formation. We propose the first Spitzer observations of DC 314.8-5.1, an isolated, optically-opaque globule that promises to be an excellent test of physical conditions and dust properties in such regions. The distance to the globule - and hence parameters that depend on distance - are well constrained by its serendipitous association with a B-type field star. This circumstance also provides an opportunity to study the interaction of the globule with the UV flux from the B-type star. We propose a coordinated suite of IRAC, MIPS and IRS observations designed to probe the physics and chemistry of interstellar material in the globule and resolve the question of whether there is significant current star formation. IRAC and MIPS images will be used to extend to longer wavelengths an existing 2MASS survey of the stellar content of the region, providing reliable discrimination between young stellar objects and reddened background stars. IRS pointed and mapping observations will be used to detect and study PAH emission features in the reflection nebula surrounding the embedded star, the relative strengths of which constrain the ionization state of the carrier molecules. High resolution IRS staring mode observations will also be obtained to search for CO2 ice absorption at 15 microns toward two point sources with high extinction. Results will enable us to compare physical conditions and dust properties in this isolated globule with those prevailing in prototypical dense environments, including cores within dark clouds (e.g. Taurus), and reflection nebulae illuminated by embedded YSOs (e.g. NGC 7023).

Spitzer Space Telescope - General Observer Proposal #20052

IRAC and MIPS Observations of IC 1805

Principal Investigator: Sidney Wolff
Institution: NOAO

Technical Contact: Luisa Rebull, SSC

Co-Investigators:
Steve Strom, NOAO
Luisa Rebull, SSC
Joan Najita, NOAO
Lynne Hillenbrand, Caltech
John Stauffer, SSC
Jane Greaves, University of St Andrews
Ian Bonnell, University of St Andrews

Science Category: Star Formation
Observing Modes: IracMap MipsPhot
Hours Approved: 11.8

Abstract:
To date, solar-type stars (M < 1 Msun) have been a main focus of Spitzer observations aimed at understanding the initial phases of disk evolution - as disks transition from the accretion phase (3-10 Myr) to the very early debris disk phase (10-30 Myr). By comparison, disks in comparable evolutionary phases surrounding intermediate mass stars have received only modest attention. Because accretion disks (ADs) are more massive (5-10x) and shorter-lived (~10x) among stars with M > 2 Msun, the initial conditions (timescale, surface density) for planet formation should be significantly different. How do these differences manifest themselves as disks surrounding these stars evolve from the AD to early debris disk phases? Could short AD lifetimes inhibit giant planet formation via core accretion? Or might giant planets form quickly via gravitational instability, and produce relatively high optical depth disks with large holes interior to the planet? We propose an IRAC and MIPS study of the young (1-3 Myr) cluster IC 1805. This region contains one of the richest known (N~400) populations of 2-8 Msun young stars - a sample large enough to track the early evolution of disks. Our goals are to (a) determine the fraction of stars as a function of time and mass having IR SEDs consistent with optically thick ADs to provide thereby robust estimates of AD lifetimes as a function of mass for 2-8 Msun stars; (b) use IRAC colors and MIPS-24 measurements to (i) diagnose the fraction of flared and flat ADs and thus constrain dust settling timescales; (ii) search for 'transition disks' which lack evidence for small grains in their inner disk but have robust 24 um excesses indicative of a significant grain population beyond several AU; (c) use the 3.6-24 um SEDs to constrain the radial distribution of dust among a potentially large sample of debris disks and to provide insight into the physical processes that sculpt the solid matter distribution.

Spitzer Space Telescope - General Observer Proposal #40321

A Deep and Wide View of the RCW 108 Star Forming Complex

Principal Investigator: Scott Wolk
Institution: Smithsonian Astrophysical Observatory

Technical Contact: Scott Wolk, Smithsonian Astrophysical Observatory

Co-Investigators:
S. Thomas Megeath, University of Toldeo
Robert Gutermuth, SAO
Tyler Bourke, SAO
Gary Melnick, SAO

Science Category: star formation
Observing Modes: IracMap MipsPhot
Hours Approved: 9.7

Abstract:
At a distance of only 1.3 kpc the embedded high mass cluster RCW 108-IR, powered by a pair of O stars (O6-O8), lies at the heart of an optically obscured, but highly IR-luminous region within the Ara OB1 association. Chandra observations detect over 400 X-ray sources in this region, but many lack near-infrared counterparts even in deep ground based observations - particular in the core of the embedded cluster. Detailed analysis of Chandra X-ray data of RCW 108 reveals the existence of at least 3 distinct regions actively forming stars in this complex - all may be triggered by winds or photoevaporation from the O stars at the center of NGC 6193. This hypothesis is supported by the association of each region with clouds of molecular gas and dust, and with clusterings of stars with K-band excess, with morphological structures indicative of an external influence. Here we propose to map this complex using IRAC and MIPS, and combine these data with our Chandra data with the following goals: 1) To probe for the most embedded objects within the young clusters and identify protostellar members, to obtain a complete census of young stars in the regions, and so to study the evolution of the the very young massive cluster RCW 108-IR and the nearby clustered regions. 2) To study the disk evolution among 4 related clusters (including the more evolved NGC 6193) to determine how environment effects disk evolution. 3) To examine the evidence for external influences on the evolution of these regions, and study the role of triggered star formation within them.

Spitzer Space Telescope - Archive Research Proposal #50145

Archival Survey of Orion A with Spitzer, XMM-Newton and Chandra

Principal Investigator: Scott Wolk
Institution: Harvard Smithsonian Center for Astrophysics

Technical Contact: Scott Wolk, Harvard-SAO

Co-Investigators:
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Robert Gutermuth, SAO
Salvatore Salvatore, INAF
Phil Myers, SAO
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John Stauffer, IPAC
Luisa Rebull, IPAC
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John Bally, University of Colorado
Joanna Oliveira, Keele
Fred Walter, SUNY Stony Brook

Science Category: star formation
Dollars Approved: 75000.0

Abstract:
We propose an archival project to combine data from the Spitzer GTO surveys of the Orion A cloud with archival XMM-Newton and Chandra observations of the same region and our own ground based spectra to better understand star formation in the nearest giant molecular cloud. To understand the evolution of stars and disks in the first million years requires a large sample. The Spitzer Orion GTO surveys contain 1800+ Class 0, I, and II stars and an unknown number of Class III sources. The X-ray observations, which include over 2000 sources, are the premier method of identifying the remaining young stars WITHOUT disks. Combining these data with ground based optical spectra and sub-mm observations we will: - Identify the PMS stars without disks. - Determine the demographics of stars (clusters, groups, isolation) as a function of evolutionary class. - Study the relative importance of clustered versus isolated star formation. - Examine the effect of environment on star formation and disk evolution. - Examine the relative duration of the Class II and transition disk phases and the commonality of inner disk holes. - Study the evolution of the X-ray emitting plasma from the protostellar to the pre-main sequence phases. - Study the possible effect of X-rays on evolving disk systems. GMCs are the dominant sites of star formation in our Galaxy. The combination of data from optical, infrared and sub-mm surveys will provide the most complete survey of star formation in a GMC to date. With these data, we hope to better understand the star forming process in GMCs, and what distinguishes these massive clouds from nearby dark cloud complexes such as Taurus and Ophiuchus.

Spitzer Space Telescope - General Observer Proposal #40563

In search of Class I brown dwarfs

Principal Investigator: Kenneth Wood
Institution: University of St Andrews

Technical Contact: Kenneth Wood, University of St Andrews

Co-Investigators:
Alexander Scholz, St. Andrews
Tom Robitaille, St. Andrews
Jane Greaves, St. Andrews

Science Category: star formation
Observing Modes: MipsPhot
Hours Approved: 8.6

Abstract:
Class I objects are the progenitors of classical T Tauri (Class II) stars. Recent surveys in star-forming regions, partly based on Spitzer data, have shown that the T Tauri population extends down to objects with only 5-15 Jupiter masses, the bottom of the Initial Mass Function. The origin of these ultra-low mass Class II sources is unclear. One way to constrain their nature is to search for their progenitors: Class I sources with substellar or even planetary masses. This is the aim of this proposal. Currently available Spitzer surveys (e.g., C2D) are not deep enough to detect these 'proto brown dwarfs'. We found that the current MIPS surveys are only sensitive down to 0.5mJy, while ultra-low mass Class I sources are expected to have 24mu fluxes down to 0.05 mJy. Broad wavelength coverage in the mid-infrared is mandatory for a reliable discrimination between Class I, Class II, and background objects. Therefore we propose to carry out a new, deep 24mu survey in the young, compact cluster NGC1333 located in the Perseus star forming region, known for a rich Class I population. We have developed a grid of SED models, together with a SED fitting machine, tailored for large object samples. It has been demonstrated that this grid is able to determine the evolutionary status of young stellar sources reliably based on Spitzer colours. We will combine the new 24mu data with publicly available IRAC data, and use the SED fitting machine to identify the lowest mass Class I sources in NGC1333. This candidate sample is the ideal starting point for dedicated follow-up observations, e.g. submm imaging and interferometry as well as near-infrared spectroscopy. Once confirmed as Class I brown dwarfs, these objects will serve as a valuable probe for the bottom of the Class I mass function as well as the origin of brown dwarfs.

Spitzer Space Telescope - Directors Discretionary Time Proposal #477

A Spitzer study of the extreme outburst of EX Lup

Principal Investigator: Peter Abraham
Institution: Konkoly Observatory

Technical Contact: Peter Abraham, Konkoly Obs.

Co-Investigators:
Thomas Henning, Max-Planck-Institut for Astronomie
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Agnes Kospal, Konkoly Observatory
Attila Moor, Konkoly Observatory
Laszlo Mosoni, Konkoly Observatory
Nikoletta Sipos, Konkoly Observatory
Aurora Sicilia Aguilar, Max-Planck-Institut for Astronomie
Roy van Boekel, Max-Planck-Institut for Astronomie

Science Category: young stellar objects
Observing Modes: IrsStare MipsPhot MipsSed
Hours Approved: 0.9

Abstract:
EX Lupi is the prototype of EXors, a class of pre-main sequence eruptive variables defined by their unpredictable brightenings which typically last several months. Since 2008 January EX Lup is unusually bright and apparently entered a new outburst period. It reached an extreme peak brightness of 8 mag, brighter than at any time before. We propose to observe EX Lup during its most extreme eruption with the Spitzer Space Telescope, in order tomeasure the 3.6-70 micrometer spectral energy distribution and perform mid-infrared spectroscopy. Using the new Spitzer data we will compare the quiescent and outburst states by analysing the wavelength-dependence of the outburst and interpret the results in terms of disk temperature/density structure. We will also analyse the silicate spectral features in order to look for the formation of crystalline silicates, never seen in young eruptive stars before. We request 1.4 h observing time for this program.

Spitzer Space Telescope - Directors Discretionary Time Proposal #524

Spectral evolution and dust mixing in the recently erupted disk of EXLup

Principal Investigator: Peter Abraham
Institution: Konkoly Observatory

Technical Contact: Peter Abraham, Konkoly Observatory

Co-Investigators:
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Thomas Henning, Max-Planck-Institut for Astronomie
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Science Category: young stellar objects
Observing Modes: IrsStare
Hours Approved: 0.5

Abstract:
This proposal is a follow-up of our previous Spitzer DDT PID 477, where we observed the young eruptive star EX Lup during its outburst, and detected on-going silicate crystal formation for the first time in a young eruptive star. We argue that spectral evolution at mid-infrared wavelengths takes place also in the fading phase of the outburst, and we request two new IRS observations to complete our spectral monitoring program and document the spectral changes. The data will help to characterize the newly formed crystal population, and provide important insight into the mixing processes in the disk. Spitzer/IRS is the only instrument we could use for our program. We request 0.5 hours observing time. Since the propose date of the first observation is early October 2008, this is a time-critical program.

Spitzer Space Telescope - General Observer Proposal #20302

A Spitzer imaging study of a selected sample of prestellar cores

Principal Investigator: Philippe Andre
Institution: CEA Saclay

Technical Contact: Philippe Andre, CEA Saclay

Co-Investigators:
Nicolas Peretto, CEA Saclay, France
Aurore Bacmann, Observatoire de Bordeaux, France
Jeroen Bouwman, MPIA Heidelberg, Germany
Derek Ward-Thompson, Cardiff University, UK
Kengo Tachihara, Astrophysical Institute, Jena, Germany
Toshikazu Onishi, Nagoya University, Japan

Science Category: young stellar objects
Observing Modes: IracMap MipsScan
Hours Approved: 26.5

Abstract:
We propose a dedicated imaging study with both IRAC and MIPS of six nearby prestellar cores spanning a range of environmental conditions. These cores, which have previously been mapped at 7 microns with ISOCAM and/or 1.3mm with the IRAM 30m telescope, are believed to be representative of the initial conditions for protostellar collapse. Some of them apparently feature sharp outer edges, possibly corresponding to a dramatic change in the thermal properties of the gas/dust at the interfaces with the ambient cloud. We expect these starless cores to be seen absorption with IRAC at 3.6-8 microns and MIPS at 24 microns and in emission with MIPS at 160 microns. Our proposed multi-wavelength imaging with Spitzer will allow us to obtain unique constraints on their outer temperature structure and on the physical nature of their apparently sharp interfaces with their parent clouds. The improved resolution of IRAC over ISOCAM will also allow us to probe, for the first time, the small-scale structure of these objects (and possible sub-fragmentation into multiple systems).

Spitzer Space Telescope - Archive Research Proposal #20663

A Combined Spitzer IRAC/MIPS/IRS and XMM-Newton Survey of the Taurus Molecular Cloud

Principal Investigator: Marc Audard
Institution: Columbia University

Technical Contact: Marc Audard, Columbia University

Co-Investigators:
Manuel Guedel, Paul Scherrer Institut
Deborah Padgett, Spitzer Science Center
Sebastian Wolf, Max Planck Institute for Astronomy
Kevin Briggs, Paul Scherrer Institut
Sergio Fajardo-Acosta, Spitzer Science Center
Adrian Glauser, Paul Scherrer Institut
Patrick Morris, Spitzer Science Center
Luisa Rebull, Spitzer Science Center
Stephen Skinner, University of Colorado
Karl Stapelfedlt, Jet Propulsion Laboratory

Science Category: young stellar objects
Dollars Approved: 80000.0

Abstract:
We propose to mine the Spitzer IRS data archive to complement our Spitzer IRAC/MIPS and XMM-Newton X-ray surveys of the Taurus Molecular Cloud (TMC). We will combine the Spitzer data with those obtained in the X-ray regime with XMM-Newton. Our goals are i) to reconstruct the detailed spectral energy distributions of young stellar objects in TMC. Our disk models will provide a comprehensive description of the circumstellar disks in young stars; ii) to combine infrared dust and gas modeling with X-ray spectroscopy. We will derive estimates of the total gas masses, of gas-to-dust ratios, and of disk surface ionization; iii) to determine the role of X-ray irradiation for heating, ionization, and disk chemistry. The Spitzer IRAC, MIPS, and IRS data in combination with the XMM-Newton data provide a unique opportunity to study in detail the structure and composition of circumstellar disks and envelopes in stars from the deeply embedded stage to the accretion-free stage of weak-lined T Tauri stars, and to determine the role of X-rays in these systems.

Spitzer Space Telescope - General Observer Proposal #41019

Catching the Post-Outburst State of the Erupting Star V1118 Ori

Principal Investigator: Marc Audard
Institution: Observatoire de Geneve

Technical Contact: Marc Audard, Observatoire de Geneve

Co-Investigators:
Manuel Guedel, Paul Scherrer Institute
Stephen Skinner, University of Colorado
Guy Stringfellow, University of Colorado
Kevin Biggs, Paul Scherrer Institute
Frederick Walter, SUNY Stony Brook
Edward Guinan, Villanova University
Ryan Hamilton, New Mexico State University

Science Category: young stellar objects
Observing Modes: IracMap IrsStare MipsSed
Hours Approved: 2.7

Abstract:
We propose to catch the post-outburst state of the young accreting star V1118 Ori with Chandra and Spitzer. V1118 Ori underwent an optical outburst in January 2005 and has now returned to a ‘‘quiescent’’ state. Our X-ray monitoring observations have shown that the X-ray spectrum softened after the outburst, maybe due to changes in the magnetic structure near the star as a result of the increased accretion load. Our long-term monitoring indicates that the X-ray flux correlates with the optical flux, a signature that accretion can impact the X-ray emission of outbursting young stars. We propose also to obtain the post-outburst spectral energy distribution in the mid-infrared with Spitzer. We will compare the new data with those taken by us in the early phase of the outburst.

Spitzer Space Telescope - General Observer Proposal #50654

Testing the Evolution of Young Stars with FU Orionis Objects

Principal Investigator: Marc Audard
Institution: Observatoire de Geneve

Technical Contact: Marc Audard, Observatoire de Geneve

Co-Investigators:
Carla Baldovin Saavedra, University of Geneva
Andres Carmona, University of Geneva
Thierry Lanz, University of Maryland

Science Category: young stellar objects
Observing Modes: IrsStare
Hours Approved: 2.7

Abstract:
FU Orionis objects (FUors) play a central role in the study of the evolution of young stars. They undergo accretion outbursts that can bring up to about 0.01 solar masses per outburst, therefore providing a significant amount of mass in the pre-main sequence life of a star. Spitzer IRS observations of FUors have shown either silicate features in absorption and ice bands or silicates in emission with no ice bands. This led some authors to propose an evolutionary paradigm in which the former FUors are younger than the latter FUors. The FUor phase might be a common but rarely observed phase (about 20 FUors known) of most young low-mass stars and might be the link between Class I and Class II sources. So far, Spitzer has obtained IRS spectra of about half of the FUor catalog, focusing on its most famous class members. With this short Spitzer proposal, we aim to observe FUors that have not yet been observed with the IRS or had no high-resolution module spectra. We will study the composition and evolution of dust grains and of ices in FUors surrounded by envelopes, and we aim at detecting faint molecular hydrogen and atomic lines with the high-resolution module spectra. The IRS spectra will probe the stellar environment, and thus test the above evolutionary paradigm and the different theories for the origin of FUor outburst. The Spitzer IRS observations of our sample of FUors will therefore provide additional insights about a significant phase in the life of young stars with the aim to better describe the evolutionary sequence from Class I star to Class II sources.

Spitzer Space Telescope - General Observer Proposal #50807

Spitzer IRS follow-up of low-luminosity objects in Taurus

Principal Investigator: Carla Baldovin Saavedra
Institution: University of Geneva

Technical Contact: Carla Baldovin Saavedra, University of Geneva

Co-Investigators:
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Deborah Padgett, SSC
Luisa Rebull, SSC
Karl Stapelfeldt, JPL
Susan Terebey, California State University Los Angeles
Lynne Hillenbrand, Caltech
Manuel Guedel, ETH Zurich
Adrian Glauser, ETH Zurich

Science Category: young stellar objects
Observing Modes: IrsStare
Hours Approved: 15.5

Abstract:
We propose to obtain IRS spectra of a sample of low-luminosity young stars in the Taurus Molecular Cloud that were identified in our Spitzer IRAC and MIPS Legacy survey of the cloud complex. Our sample contains Class 0/I and II sources, transitional disks, edge-on disks, and brown dwarfs with accretion disks. This IRS follow-up proposal is complementary to the IRS GTO program on previously known, bright Taurus members and will provide information on the disk properties of hitherto unknown low-mass and sub-stellar objects. Our goals include a comparison of IRS spectra low-luminosity members and the bright members; a determination of the proto-planetary disk properties; a quantification of dust processing in their disks; and a study of the properties of transitional disks and enveloppes in embedded protostars..

Spitzer Space Telescope - General Observer Proposal #30849

IRS Scan Mapping of IRAS16253-2429: A Textbook Example for Unlocking the Secrets of Protostellar Outflows

Principal Investigator: Mary Barsony
Institution: San Francisco State University

Technical Contact: David Ciardi, Michelson Science Center

Co-Investigators:
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David Ciardi, Michelson Science Center/Caltech
David Cole, JPL
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Grace Wolf-Chase, Adler Planetarium/University of Chicago
Jason Ybarra, San Francisco State University

Science Category: young stellar objects
Observing Modes: IrsMap
Hours Approved: 11.7

Abstract:
IRAS 16253-2429 is a newly discovered Class 0 protostar in the nearby Rho Ophiuchi molecular clouds. Ground-based imaging tracing its 2.12 micron H2 emission and CO(3-2) molecular line maps reveal its bipolar, molecular outflow. The IRAC images from the Spitzer archive show a beautiful, bipolar hourglass structure, tracing the outflow cavities, in addition to shock features from the flow. The requested IRS scan mapping is necessary to separate the pure shocked molecular line emission associated with the flow, from the scattered dust continuum emission of the cavity, and from the PAH (polycyclic aromatic hydrocarbon) feature emission found throughout the Rho Oph clouds. Hydrodynamic jet models , including molecular chemistry and cooling, can then be quantitatively compared with the IRS scan maps to infer jet characteristics, such as the presence of an underlying pulsed, continuous, and/or precessing jet. The uniqueness of IRAS16253-2429 stems from the fact that its infall envelope is seen in absorption against the bright background PAH emission of its parent cloud, which is backlit by the FUV/UV light of the Sco OB2 association. This means we can derive the infallenvelope's density distribution (at multiple wavelengths, with IRS scan mapping), as well as the outflow cavities' density distributions at the highest spatial resolution ever achieved for a Class 0 protostar. The derived envelope density distribution will then serve as input for hydrodynamic models of jet-driven and wide-angled wind driven cavities. The predicted cavity density distributions from these models will then be quantitatively compared with the observations to infer the nature of the driving wind/jet at this very early protostellar stage.

Spitzer Space Telescope - General Observer Proposal #20755

A Multi-epoch IRS Accretion Variability Study of Actively Accreting T Tauri Stars

Principal Investigator: Jeffrey Bary
Institution: University of Virginia

Technical Contact: Jeffrey Bary, University of Virginia

Co-Investigators:
Michael Skrutskie, University of Virginia
Dawn Peterson, University of Virginia

Science Category: young stellar objects
Observing Modes: IrsStare
Hours Approved: 8.4

Abstract:
We propose to use Spitzer and IRS in SL1 and SL2 modes to make multiple observations of actively accreting T Tauri stars during the course of Cycle 2. In coordination with an ongoing near-infrared spectroscopic survey of the same sources, we hope to characterize the time dependence and nature of accretion variability in these sources and determine if a correlation exists between inner and outer disk accretion activity. We expect the accretion variability to manifest itself as fluctuations in the shapes of the near-IR and mid-IR spectral energy distributions as well as variations in the line strength and shapes of accretion-related emission line features.

Spitzer Space Telescope - General Observer Proposal #3434

The Structure and Content of Pre-Stellar Massive Cores

Principal Investigator: Edwin Bergin
Institution: University of Michigan

Technical Contact: Edwin Bergin, University of Michigan

Co-Investigators:
Lori Allen, Smithsonian Astrophysical Observatory
Tracy Huard, Smithsonian Astrophysical Observatory
David Wilner, Smithsonian Astrophysical Observatory

Science Category: young stellar objects
Observing Modes: IracMap MipsPhot
Hours Approved: 3.9

Abstract:
Significant progress has been made in understanding the formation of low-mass stars like the Sun through detailed studies of isolated pre-stellar dense cores in nearby dark clouds. Much less progress has been made in understanding the formation of high-mass stars, in part because they are intrinsically rare, short lived, and more distant, but also because the initial phase-- the pre-stellar massive core -- has not been identified. The recent MSX survey of the Galactic Plane has allowed us to construct a catalog of 114 candidate pre-stellar massive cores selected for high extinction (8 micron opacity), proximity to known sites of high-mass star formation, and lack of embedded sources. We have imaged 50 of these candidates in various molecular lines at millimeter wavelengths and find close correspondence between the molecular emission and the dark patches of extinction seen in the mid-infrared. Because of selective depletion of molecules onto cold dust grains, the chemical characteristics of these regions provide an indicator of evolutionary state. We propose to use the Spitzer Space Telescope to observe a sample of these candidate pre-stellar massive cores with the following goals: (1) to search for deeply embedded luminosity sources within the cores using IRAC and MIPS to confirm that they do not harbor any stars to very low luminosity limits, (2) to map the unknown physical structure of the cores using IRAC images to measure extinction against background stars as well as the diffuse Galactic background, and (3) to correlate the derived physical structures of these cores with the known chemical properties to place them in an evolutionary context, similar to that of their low-mass brethren.

Spitzer Space Telescope - General Observer Proposal #50537

Variability in PMS Circumbinary Disks

Principal Investigator: Andrew Boden
Institution: California Institute of Technology

Technical Contact: Andrew Boden, California Institute of Technology

Co-Investigators:
Rachel Akeson, IPAC/Caltech
David Ciardi, IPAC/Caltech
Carl Grillmair, IPAC/Caltech

Science Category: young stellar objects
Observing Modes: IrsStare
Hours Approved: 5.1

Abstract:
In the canonical model of star formation, the role of multiplicity remains an open issue, particularly in the formation and evolution of circumstellar and circumbinary disks. We propose to use Spitzer/IRS observations to measure variations in circumbinary disk emission with orbital phase in two pre-main sequence binaries. Variations in continuum spectral slope and silicate line strength and shape are expected from changes in the stellar illumination of the inner disk with orbital phase. These observations will probe the disk structure and composition, serving as a test of predictions made by dynamical models.

Spitzer Space Telescope - Legacy General Observer Proposal #139

From Molecular Cores to Planets

Principal Investigator: Neal Evans
Institution: University of Texas

Technical Contact: Neal Evans, University of Texas

Co-Investigators:
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Geoffrey Blake, California Institute of Technology
Paul Harvey, University of Texas at Austin
David Koerner, University of Pennsylvania
Lee Mundy, University of Maryland
Philip Myers, Smithsonian Astrophysical Observatory
Deborah Padgett, Spitzer Science Center
Anneila I. Sargent, California Institute of Technology
Karl Stapelfeldt, Jet Propulsion Laboratory
Ewine van Dishoeck, Leiden University

Science Category: young stellar objects
Observing Modes: IracMap MipsPhot
Hours Approved: 400.0

Abstract:
The formation of stars and planets from molecular cloud cores is a key area for research this decade. Crucial steps in this process can only be studied at mid-infrared to far-infrared wavelengths, where SIRTF provides an unprecedented improvement in sensitivity. We propose to use SIRTF (IRAC, MIPS, and IRS) to obtain data that span the evolutionary sequence from cores to planets, including a sampling of other variables, such as mass and environment, sufficient to separate these variables from evolution. In addition to observing known sources, we will scan large areas in molecular clouds for low luminosity sources and make a complete sample of nearby solar-type stars for debris disks. Spectroscopy of known objects spanning the full evolutionary range will be complemented by follow-up spectroscopy on new objects found in the surveys. The resulting data products will include catalogs of thousands of previously unknown sources, multiwavelength maps of very large regions, spectra of hundreds of sources, ancillary data, and new tools for analysis and modeling. These will provide many opportunities for follow-up studies with SIRTF, other space missions, including SIM, NGST, and TPF, and ground-based telescopes.

Spitzer Space Telescope - Directors Discretionary Time Proposal #232

Deep IRAC and MIPS 160 Imaging of L1014

Principal Investigator: Neal Evans
Institution: University of Texas

Technical Contact: Deborah Padgett, California Institute of Technology

Co-Investigators:
The c2d Team ,

Science Category: young stellar objects
Observing Modes: IracMap MipsPhot
Hours Approved: 1.2

Abstract:
This program obtain deep IRAC and MIPS 160 observations of L1014 -- a "starless" core. These data will supplement the shallow IRAC and MIPS 24, 70 data obtained with the C2D Legacy program.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #219

Dark Clouds

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Sean Carey, SSC

Science Category: young stellar objects
Observing Modes: IracMap MipsPhot
Hours Approved: 1.1

Abstract:
This program will map three infrared dark-clouds (IRDCs) with IRAC and embedded massive protostars within the IRDCs with MIPS. IRDCs are large, cold, dense molecular cores with substantial mid-infrared extinction (> 1 mag from 8-25 microns). IRDCs have gas densities of 10^6 cm^-3 and temperatures of 8-15K. IRDCs contain bright submillimeter sources with molecular outflow and infall signatures. The available data suggests these sources are massive class 0 protostars. This program will measure the embedded protostellar/young stellar content of the IRDCs and measure the mid-infrared extinction curve towards these objects. A total of 73 minutes of observing time with IRAC and MIPS is required.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30319

Exploring the Time Domain: IRAC Photometric Monitoring of the Serpens Cloud Core

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: John Stauffer, Spitzer Science Center

Co-Investigators:
John Stauffer, SSC/JPL
Luisa Rebull, SSC
S. Tom Megeath, CfA
Lori Allen, CfA
David Barrado y Navascues, LAEFF, Spain

Science Category: young stellar objects
Observing Modes: IracMap
Hours Approved: 15.4

Abstract:
In the past year, several programs have demonstrated that IRACcan provide extremely accurate and stable time-series photometry. This scientific capability has so far been used to detect the thermal emission of extra-solar planets and to attempt to detect cloud formations in the photospheres of brown dwarfs (brown dwarf "weather"). We believe there is another topic where IRAC's very stable photometry can break new ground. We propose to use IRAC to monitor a set of 50-100 very young PMS stars in the embedded star-forming region of the Serpens cloud core. Most of the stars in this region are too embedded to monitor at optical wavelengths. Monitoring could be done from the ground in the near-IR, but we believe the much better stability (both photometric and PSF width/shape) provided by IRAC will allow fundamentally different science to be considered with our Spitzer data. The variability of PMS stars has been the subject of considerable effort in the optical and in the near-IR, but this will be the first significant attempt with IRAC and by far the most sensitive PMS star monitoring program ever attempted in the mid-IR. Based on previous optical and near-IR efforts, we expect to see variability due to rotational modulation and flaring. We hope in addition we will be able to measure or place limits on the time variability of the accretion onto the star as reflected by the contribution to the system light of the inner disk wall. We regard this as an exploratory program - if we detect variability in a significant fraction of the Serpens members and if we can tie that variability to specific mechanisms that provide new insight into how stars are assembled, then we expect our observations will encourage others to propose similar programs for other regions.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40005

MIPS imaging of infrared PDRs

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Luis Chavarria, Smithsonian Astrophysical Observatory

Co-Investigators:
Luis Chavarria, Cfa
Lori Allen, CfA
Joseph Hora, CfA

Science Category: young stellar objects
Observing Modes: MipsScan
Hours Approved: 12.0

Abstract:
We propose to image eight star-forming regions using MIPS. These data will complement existing IRAC and ground-based near-IR and optical images, as well as optical, near-IR and mm-wave spectra in these regions. While the existing data provide much information about these star-forming regions, the MIPS data are needed to identify the protostars. The targets of this proposal include eight of the nine star-forming regions with prominent infrared photodissociation regions that were imaged with IRAC during the first GTO cycle (PID201). MIPS data for the ninth region, AFGL 4029, was obtained in the cycle-2 GTO program of Allen et al. (W5). These regions, at distances of 2-3 kpc, contain hundreds of young stars, and in some cases, multiple generations of star formation. The MIPS data are especially helpful in identifying the very youngest populations, enabling a census of current star formation.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40006

Distributed vs. Clustered Star Formation in Mon OB1 - NGC 2264

Principal Investigator: Giovanni Fazio
Institution: Smithsonian Observatory CfA

Technical Contact: Judith Pipher, University of Rochester

Co-Investigators:
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S. Thomas Megeath, U. Toledo
Lori Allen, Smithsonian CfA
Phillip Myers, Smithsonian CfA

Science Category: young stellar objects
Observing Modes: IracMap MipsScan
Hours Approved: 8.6

Abstract:
Following successful IRAC + MIPS observations (75% complete) of the GMCs Cep OB3 and Mon R2 harboring high mass star formation in PID 20403 "Distributed vs. Clustered Star Formation", we propose in this cycle to obtain similar observations for 2 more GMCs, namely Mon OB1 and Cam OB1. The present GTO proposal begins this program by covering part of the distributed area around NGC 2264 in Mon OB1. The rest of Mon OB1 as well as Cam OB1 will be proposed as a GO program. We hope to establish the physical conditions leading to clustered vs. distributed star formation. We will compare results for all these regions against similar studies in clouds harboring low mass star formation, for example, the c2d survey.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #43

An IRAC Survey of the L1630 and L1641 (Orion) Molecular Clouds

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Tom Megeath, Harvard, CfA

Science Category: young stellar objects
Observing Modes: IracMap MipsScan
Hours Approved: 45.3

Abstract:
We will conduct a survey of the Orion A (L1641) and Orion B (l1630) Molecular Clouds in all four IRAC bands. From this survey we can achieve the following: 1.) probe the spatial distribution of young stars in the Orion clouds, comparing the number of clustered and isolated stars, 2.) study the evolution of circumstellar disks and envelopes during the first few millions years of pre--main sequence evolution, and 3.) measure the Orion cloud IMF down to 10-20 Mjupiter.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50244

IRAC imaging of Protocluster AFGL 5157 (NH3)

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Jiasheng Huang, CfA

Co-Investigators:
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Yiping Ao, Purple Mountain Obs.
Yafeng Chen, Purple Moutain Obs.
Ruiqing Mao, Purple Moutain Obs.

Science Category: young stellar objects
Observing Modes: IracMap
Hours Approved: 2.4

Abstract:
Formation of star in groups and/or clusters is one of the most important but unanswered questions in the study of galactic star formation. AFGL 5157 (NH3) is a unique case undergoing present cluster formation, as proved by the following key facts: (1), There is no detectable NIR point source within the loci of dense NH3 core, known from recent ground-base NIR imaging but a radio continuum source and some H2O masers were found within the core. (2) Within the NH3 core, multiple H2 jets have been found and about 10 protostellar objects are responsible for the jets; (3), NMA and SMA detected 14 dust continuum point sources at 3sigma level of 2 mJy/beam. (4) High-resolution CO imaging at NMA found a collimated CO jet well matching one of the major NIR H2 jet. In this study, we propose to observe AFGL 5157 (NH3) by IRAC deep Imaging, Our major purposes are as following: (1), To detect the cluster by IRAC and to conduct photometry and to establish the SED of Class 0/1 objects. (2) To build the luminosity function of the cluster, which, combined with the ground-base observations on the distribution of protostellar members, should be able to provide, the first of its kind, luminosity function of a cluster under formation. (3), To make deep imaging for the jets and outflows within the region. The results will provide crucial information to locate the evolutionary status of each cluster member.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #6

Structure and Incidence of Young Embedded Clusters

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Tom Megeath, Harvard-CfA

Science Category: young stellar objects
Observing Modes: IracMap MipsScan
Hours Approved: 49.8

Abstract:
We plan to use the IRAC and MIPS cameras on SIRTF to measure the spatial distribution of the youngest stars in ~ 24 groups and clusters within 1 kpc, and to measure the degree of clustering in 7 star-forming complexes within 350 pc. This program will allow us for the first time to determine systematically how stars in clusters are arranged at birth--their organization into groups, the number, spacing, and density of these groups, their range of stellar ages and their distribution of stellar masses. These observations should strongly constrain models of cluster formation and of the initial mass function.

Spitzer Space Telescope - Archive Research Proposal #40728

All c2d Spitzer Outflows

Principal Investigator: Alyssa Goodman
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Jens Kauffmann, Harvard-SAO

Co-Investigators:
Jens Kauffmann, Harvard-Smithsonian CfA
Hector Arce, American Museum of Natural History
Karl Stapelfeldt, JPL, Pasadena
Neal Evans, University of Texas, Austin
Lori Allen, Harvard-Smithsonian CfA
Tyler Bourke, Harvard-Smithsonian CfA
Tracy Huard, Harvard-Smithsonian CfA
Michelle Borkin, Harvard IIC
Jaime Pineda, Harvard-Smithsonian CfA
Jonathan Foster, Harvard-Smithsonian CfA

Science Category: young stellar objects
Dollars Approved: 64181.0

Abstract:
Protostellar outflows can be well identified as diffuse knots in Spitzer IRAC images. We therefore propose to systematically search and characterize all outflows covered by the most extensive Spitzer imaging survey of local star formation, the Cores to Disks (c2d) Spitzer Legacy Program. This would create an extensive, homogenously studied (publicly available) legacy-style outflow sample without biases, likely the most comprehensive one available to date. It would replace existing studies that usually employ different methods for different regions, and do never probe a volume of the scale covered by c2d (5 large cloud complexes and about 90 isolated dense molecular cores). Our homogenous approach would, e.g., also allow to see known outflows in a new light, since existing analysis (e.g., on the geometry) is hard to compare between different samples. Furthermore, also young stellar objects can be well identified and characterized using Spitzer IRAC and MIPS images. This allows to probe the sources driving outflows, again in a more homogenous fashion than possible for previous studies. Based on existing complementary c2d data, which covers the 1 to 1000 micron wavelength range, we would derive protostellar properties (like bolometric luminosity and temperature) and associate these with the outflow properties. Thus, Spitzer?s unparalleled sensitivity to both outflows and stars offers the unique chance to systematically relate the properties of outflows to the ones of the driving sources without biases. No grande-scale study of this type has been conducted so far, in particular none relying on a single, homogenous dataset covering a significant fraction of the local star formation. Our survey would, e.g., be critical in gauging the relative abundance of parsec-scale, ?S-shaped?, and quadrupolar outflows. This is important, given that such flows provide significant energy transfer over large (cloud-size) scales, possibly indicate jet precession, and may hint at protostellar binaries, respectively.

Spitzer Space Telescope - Archive Research Proposal #50668

An archival Spitzer study of protostars

Principal Investigator: Lee Hartmann
Institution: University of Michigan

Technical Contact: Lee Hartmann, University of Michigan

Co-Investigators:
Nuria Calvet, University of Michigan
John Tobin, University of Michigan
Elise Furlan, UCLA

Science Category: young stellar objects
Dollars Approved: 75000.0

Abstract:
We propose to use spatially-resolved imaging and spectroscopic data from Spitzer, combined with longer-wavelength studies, to develop a comprehensive picture of protostellar envelopes for a sample of young stellar objects. Radiative transfer modeling will allow us to explore the following questions: Do infalling envelopes generally form inner toroids in addition to more flattened disks, as predicted by some models with strong magnetic fields? Are most protostellar disks bright in the IRAC range, indicating rapid disk accretion in early stellar evolution? Do envelopes generally have high-albedo, i.e., larger grains? What is the nature of the interface between the infalling envelope and the cavity-producing outflow? The sample of protostars to be studied will enable us to examine whether envelope properties depend upon protostellar luminosity and/or environment. Our models will also have long-term utility, in that we will make predictions for future sub-mm and mm-wave interferometric observations constraining envelope chemistry, kinematics, and outflow-inflow interactions. This study will provide fundamental insights into protostellar collapse in particular and star formation in general.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #114

Molecular and atomic emission-line images of DR 21 and GGD 37

Principal Investigator: James R. Houck
Institution: Cornell University

Technical Contact: Dan Watson, University of Rochester

Science Category: young stellar objects
Observing Modes: IrsMap
Hours Approved: 6.5

Abstract:
Molecular and atomic emission-line images of DR 21 and GGD 37 PI: J.R. Houck Technical contact: Dan Watson DR 21 and GGD 37 (Cep A West) are two of the best-resolved examples of bipolar outflows and shocks from massive young stellar objects. In this program we will use the high-spectral-resolution modules of the IRS to obtained detailed images of emission by molecular hydrogen (three pure rotational lines), water (13 pure rotational lines) , and several low-excitation ions and atoms (e.g. [Si II], [Fe II], [S I] and [Ne II]). The structure of the shocks will be resolved in the images; in particular the dual cloud-shock/jet-shock structures will be cleanly separated in the many nearly-edge-on shock rims in these objects. This provides a unique opportunity -- not possible from suborbital platformas -- for study of the interaction of a YSO outflow and its surrounding cloud, using probes that trace the bulk of the material (H2) as well as the bulk of the radiated energy (H2O) in the shocked gas, and will provide strong constraints on models of the interaction and on the influence of outflows and shocks on ongoing star formation.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30540

Disk structure and planet formation around young low-mass stars and brown dwarfs

Principal Investigator: James R. Houck
Institution: Cornell University

Technical Contact: Kevin Luhman, Pennsylvania State University

Co-Investigators:
Dan Watson, University of Rochester
Bill Forrest, University of Rochester
Lee Hartmann, U. Michigan
Nuria Calvet, U. MIchigan
Keven Uchida, Cornell U
Elise Furlan, cornell U.
Greg Sloan, Cornell U
Paola d'Alessio, UNAM-Morelia
Luke Keller, Ithaca College
Joan Najita, NOAO
Christine Chen, NOAO
Ciska Markwick-Kemper, U. Virginia
Mike Jura, UCLA
Tom Roellig, NASA Ames
Mark Marley, NASA Ames
Amy Mainzer, JPL
Tom Megeath, CfA
Lori Allen, CfA
Giovanni Fazio, CfA
James Muzerolle, U. Arizona

Science Category: young stellar objects
Observing Modes: IracMap IrsStare
Hours Approved: 50.1

Abstract:
We propose to obtain IRS complete (5-40 micron) low-resolution spectra of a sample of 41 young low-mass stars and brown dwarfs, to study the characteristics of their disks and to search for evidence of ongoing planet formation. We also propose to use IRAC to observe an additional 43 newly-identified brown dwarfs in Taurus and Chamaeleon, for future IRS spectroscopic followup. This guaranteed-time observing program has a total of 50.1 hours, with 14 hours provided by IRAC PI Giovanni Fazio, and 36.1 hours by IRS PI Jim Houck.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30706

An IRS survey of protoplanetary disk evolution in the Orion molecular-cloud complexes

Principal Investigator: James R. Houck
Institution: Cornell University

Technical Contact: Dan Watson, University of Rochester

Co-Investigators:
Bill Forrest, University of Rochester
Lee Hartmann, U. Michigan
Nuria Calvet, U. MIchigan
Keven Uchida, Cornell U
Elise Furlan, cornell U.
Greg Sloan, Cornell U
Paola d'Alessio, UNAM-Morelia
Luke Keller, Ithaca College
Joan Najita, NOAO
Christine Chen, NOAO
Ciska Markwick-Kemper, U. Virginia
Mike Jura, UCLA
Tom Megeath, CfA
Lori Allen, CfA
Judy Pipher, U. Rochester
Kevin Luhman, Penn State U
Giovanni Fazio, CfA
James Muzerolle, U. Arizona
Kevin Flaherty, U. Arizona
George Rieke, U. Arizona

Science Category: young stellar objects
Observing Modes: IrsStare
Hours Approved: 100.5

Abstract:
We propose to obtain IRS complete (5-40 micron) low-resolution spectra of a large sample of young stellar objects with protoplanetary disks in the Orion A and B molecular cloud complexes. The aim is to study the influence of the wide range of star-formation conditions in the Orion clouds on the structure, composition and evolution of protoplanetary disks, and on the conditions and occurrence of planet formation in these disks. This guaranteed-time observing program has a total of 100.9 hours, with 20 hours provided by IRAC PI Giovanni Fazio, 20 hours by MIPS PI George Rieke, and 60.9 hours by IRS PI Jim Houck.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40145

Early T Tauri Stars with the IRS

Principal Investigator: James Houck
Institution: Cornell University

Technical Contact: James Houck, Cornell University

Co-Investigators:
William Forrest, University of Rochester
Dan Watson, University of Rochester
Nuria Calvet, University of Michigan
Paola d'Alessio, UNAM
Lee Hartmann, University of Michigan
Jesus Hernandez, University of Michigan
Aigen Li, University of MIssouri
Elise Furlan, University of California at Los Angeles
Keven Uchida, Jet Propulsion Laboratory
Greg Sloan, Cornell University
Luke Keller, Ithaca College
Joan Najita, NOAO
Christine Chen, NOAO
Ciska Markwick-Kemper, University of Manchester
Mike Jura, University of California at Los Angeles
Tom Megeath, University of Toledo
Lori Allen, CfA
Judy Pipher, University of Rochester
Kevin Luhman, Penn State U.
Giovanni Fazio, CfA
James Muzerolle, University of Arizona
Kevin Flaherty, University of Arizona
George Rieke, University of Arizona

Science Category: young stellar objects
Observing Modes: IrsStare
Hours Approved: 14.6

Abstract:
We propose to observe using the IRS a sample of 92 mostly F and G stars with well-characterized stellar photospheres to bridge the gap between the later spectral type T Tauris and the earlier type Herbig Ae/Be stars. Silicate dust properties of disks around F and G stars should be intermediate between those of classical T Tauris and Herbig Ae/Be systems. Because disk photospheric features have been observed in K and M type T Tauri star spectra and because the stellar photospheres of our sample of F and G type stars show no molecular absorption, Early T Tauri Stars are crucial in exploring disk photospheres. Also, the lack or presence of PAH features and their qualities should help give insight into the origin and nature of PAH dust in disks around young stars. In addition, spectra of these Early T Tauri stars can probe dust settling and disk structural evolution in this population. Young F and G stars, being of similar spectral type and mass to our Sun, might also shed light on the formation of our Solar System.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40302

Disk structure and planet formation around young low-mass stars and brown dwarfs

Principal Investigator: James Houck
Institution: Cornell University

Technical Contact: Kevin Luman, Pennsylvania State University

Co-Investigators:
Kevin Luhman, Penn State U
Dan Watson, U. Rochester
Bill Forrest, University of Rochester
Lee Hartmann, U. Michigan
Nuria Calvet, U. MIchigan
Elise Furlan, UCLA
Greg Sloan, Cornell U
Paola d'Alessio, UNAM-Morelia
Luke Keller, Ithaca College
Joan Najita, NOAO
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Ciska Markwick-Kemper, U. Virginia
Mike Jura, UCLA
Tom Roellig, NASA Ames
Mark Marley, NASA Ames
Amy Mainzer, JPL
Tom Megeath, CfA
Lori Allen, CfA
Giovanni Fazio, CfA

Science Category: young stellar objects
Observing Modes: IracMap IrsStare MipsPhot
Hours Approved: 22.8

Abstract:
We propose to obtain IRS complete (5-40 micron) low-resolution spectra of young stars and brown dwarfs to study the characteristics of their disks and to search for evidence of ongoing planet formation. Several of these objects exhibit evidence of inner disk holes in IRAC and MIPS measurements; the IRS data will be used to confirm the presence of these holes, which may be cleared by newly-formed planets. We also propose to use IRAC and MIPS observations of additional low-mass stars and brown dwarfs to identify new disks (particularly transition disks) for future IRS followup. This guaranteed-time observing program has a total of 23 hours.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40525

Protoplanetary disk evolution in the Orion, Serpens and Perseus clouds

Principal Investigator: James Houck
Institution: Cornell University

Technical Contact: Dan Watson, University of Rochester

Co-Investigators:
Dan Watson, University of Rochester
Bill Forrest, University of Rochester
Lee Hartmann, U. Michigan
Nuria Calvet, U. MIchigan
Elise Furlan, UCLA
Greg Sloan, Cornell U
Paola d'Alessio, UNAM-Morelia
Luke Keller, Ithaca College
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Ciska Markwick-Kemper, U. Manchester
Mike Jura, UCLA
Tom Megeath, U. Toledo
Lori Allen, CfA
Judy Pipher, U. Rochester
Kevin Luhman, Penn State U
Giovanni Fazio, CfA
James Muzerolle, U. Arizona
Kevin Flaherty, U. Arizona
George Rieke, U. Arizona
Edwin Bergin, U. Michigan
Gary Melnick, CfA
David Neufeld, Johns Hopkins U.
Robert Gutermuth, CfA

Science Category: young stellar objects
Observing Modes: IrsStare
Hours Approved: 71.5

Abstract:
We propose to obtain complete IRS low-resolution spectra (5-40 micron) of a large sample of young stellar objects with protoplanetary disks and envelopes in molecular cloud complexes in Orion B (the NGC 2024 and 2068 clusters), the NGC 1333 cluster in Perseus, and the main young cluster in Serpens. The aim is to study the influence of the wide range of well-characterized star-formation conditions represented by these clouds on the structure, composition and evolution of protoplanetary disks and protostellar envelopes, and on the conditions and occurrence of planet formation in these disks. This guaranteed-time observing program has a total of 88.4 hours, with 15 hours provided by IRAC PI Giovanni Fazio, 15 hours by MIPS PI George Rieke, and 53.4 hours by IRS PI Jim Houck.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50633

Disk accretion shocks in protostars in Orion

Principal Investigator: James R. Houck
Institution: Cornell University

Technical Contact: Dan Watson, University of Rochester

Co-Investigators:
David Neufeld, Johns Hopkins U.
Tom Megeath, U. Toledo
Lori Allen, CfA
Ted Bergin, U. Michigan
Nuria Calvet, U.Michigan
Bill Forrest, U. Rochester
Elise Furlan, UCLA/NAI
Lee Hartmann, U. Michigan
Sebastian Maret, U. Michigan
Gary Melnick, CfA
Joan Najita, NOAO
Manoj Puravankara, U. Rochester
Paule Sonnentrucker, Johns Hopkins U.
Volker Tolls, CfA
Dan Watson, U. Rochester

Science Category: young stellar objects
Observing Modes: IrsStare
Hours Approved: 10.3

Abstract:
The discovery of water and OH line emission from the embedded disks of Class 0 protostars is one of the most spectacular recent results from Spitzer, and opens one of the longest-sought regimes of star formation to detailed study: protostellar envelope infall, arrival of water (and other molecules) in the planet-forming regions of protoplanetary systems, and the process by which protoplanetary accretion disks are formed. With Spitzer-IRS we have so far detected emission in eight protostars (in IRS SL-LL observations) in addition to the original example, NGC 1333 - IRAS 4B. These objects are likely to represent the upper extreme of protostellar infall rate and disk water and OH line luminosity. Here we propose deep high-resolution IRS followup high-resolution spectroscopy on seven of these objects, to enable a particularly detailed study of the physical and oxygen-chemical state in paradigms of the very youngest protoplanetary disks, exploiting even relatively weak features of OH, water, and its rare isotopologues. This program will consume 10.3 hours of Spitzer-IRS GTO time, provided by IRS PI and co-investigator Jim Houck. In a complementary GO proposal (Watson et al.) we would conduct a survey of a complete sample of Class 0 and Class I protostars similar to those proposed here(i.e. viewed face-on), but covering the full range of properties of envelope-bearing protostars: it is chosen to span the range of mass, luminosity and age of protostars with high statistical significance, in star-forming clouds lying 140-420 pc from the Solar system, with a 5-sigma disk-accretion-rate sensitivity of 2 - 8 E-6 solar masses per year. Detection of water and OH emission from this sample will enable a physical study of the evolution of infall, envelope-disk accretion, and the physical state of protoplanetary disks, through the era of protostellar-envelope settling and dissipation, that would be of fundamental importance in the study of star formation.

Spitzer Space Telescope - General Observer Proposal #50563

Clarifying Massive Protostellar Evolution and Circumstellar Processing

Principal Investigator: Remy Indebetouw
Institution: University of Virginia

Technical Contact: Remy Indebetouw, University of Virginia

Co-Investigators:
Crystal Brogan, NRAO
Serena Viti, UCL
Barbara Whitney, Space Science Institute
Marta Sewilo, StScI
Thomas Robitaille, St Andrews
Melvin Hoare, Leeds
Stuart Lumsden, Leeds
James Urquhart, Leeds

Science Category: young stellar objects
Observing Modes: IrsMap
Hours Approved: 11.8

Abstract:
Massive stars dominate the evolution of galaxies and even as protostars, their feedback can affect their own formation and that of their host clusters. We propose a systematic study of massive protostars through the stages of their early evolution, to derive a clearer evolutionary sequence and a better link between the state of the central source and physical conditions in circumstellar material. This experiment will improve over existing work by careful source selection to systematically span evolutionary parameter space, resulting in a more uniform and comprehensive sample. Sophisticated radiative transfer, ionization, and chemical modeling will be used to extract the full riches of each IRS spectrum and find trends in how massive stars form and process their natal material: We will be able to determine the temperature, density, and chemical state (heating history) of circumstellar dust and ice in the accretion disk and envelope, and at later evolutionary stages the ionizing and soft (PAH-exciting) ultraviolet radiation emitted by the protostars and how that radiation is quenched and shadowed by circumstellar material. This investigation is the key to realizing the full potential of previous infrared imaging surveys like MSX and Spitzer's GLIMPSE and MIPSGAL to study massive star formation. These surveys have provided a basis for us to select a large relatively unbiased sample spanning evolutionary state. In return, revealing the spectroscopic signature of massive YSOs will greatly clarify the modeling and interpretation of the thousands of other protostars in these imaging survey data.

Spitzer Space Telescope - General Observer Proposal #20714

Probing environment and circumstellar disk evolution in triggered star forming regions: IRAC and MIPS imaging of bright-rimmed globules CG4/SA101 and CG30/31

Principal Investigator: Jinyoung Serena Kim
Institution: University of Arizona

Technical Contact: Jinyoung Serena Kim, University of Arizona

Co-Investigators:
William Sherry, NOAO

Science Category: young stellar objects
Observing Modes: IracMap MipsPhot
Hours Approved: 11.8

Abstract:
We propose to obtain IRAC and MIPS images of a newly discovered star forming region, cometary cloud complex CG~4/SA101 (Kim et al. 2005c). We also propose to acquire more complete IRAC and MIPS images of a cometary globule complex CG~30/31, where we found young stars (Kim et al. 2005a,c), but existing program by a Spitzer legacy team (c2d) did not observe. Both star forming complexes reside in the Gum Nebula, where early O stars, Wolf-Rayet star, supernovae remnants, and OB associations produce strong ionizing UV photons. These two star forming regions are in a photoevaporating cometary shaped bright-rimmed clouds, at few tens of parsecs away from the common center of main ionizing sources in the Gum Nebula, placing them in a 'intermediate' UV radiation field between Orion-like Strong radiation field regions and Taurus-like weak radiation field regions. We propose to perform comparative and statistical studies probing circumstellar disk characteristics and evolution in different star forming environments together with existing data of well-known star forming regions. The age range of the young stars in these regions (1-5 Myr old) is also of a great interest, because this is a time when transition from optically thick disks to optically thin debris disks occurs. Therefore, this proposed observations will provide an important dataset to study lifetime of inner disks and optically thick disk evolution in such environments. We probe yet another common mode of star formation, forming in groups in triggered mode or influenced by UV photons from nearby ionizing sources. Our dataset and study will contribute to a better understanding of star formation and circumstellar disk evolution linking well-known star forming regions in weak and strong radiation field environments. We believe that this dataset will also benefit other star formation and disk communities for various other studies in addition to existing dataset of clusters and associations, obtained by GTO, legacy, and GO1.

Spitzer Space Telescope - General Observer Proposal #20635

The earliest stages of massive star formation - Pre-Protocluster Cores and Protoclusters

Principal Investigator: Randolf Klein
Institution: Max-Planck-Institut für extraterrestrische Physik

Technical Contact: Randolf Klein, MPE

Co-Investigators:
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Thomas Henning, Max-Planck-Institut für Astronomie
Jan Forbrich, Max-Planck-Institut für Radioastronomie
Hendrik Linz, Max-Planck-Institut für Astronomie
Bettina Posselt, Max-Planck-Institut für extraterrestrische Physik
Katharina Schreyer, Astrophysikalisches Institut und Universitäts-Ster
John Tobin, University of Illinois, Urbana-Champaign
Shiya Wang, University of Illinois, Urbana-Champaign

Science Category: young stellar objects
Observing Modes: MipsPhot MipsSed
Hours Approved: 4.9

Abstract:
The unique capabilities of the Spitzer Instrument MIPS are used to investigate the mid to far infrared properties of candidates for the earliest stages of massive star formation: pre-protocluster cores and protoclusters. These candidates are selected from millimeter continuum surveys where the targets are conspicuous compact cloud cores. The youth of the selected cores is underlined by being non detected at NIR and MIR wavelengths so far. The proposed MIPS observations (24 & 70 micron photometry and SED) will reveal the SED of these pre-protocluster cores or protoclusters. The shape of the SED and the luminosity allow to draw conclusions about the central object(s) embedded in the cores and the temperature and density structure of the cores. 3D radiative transfer models are available to help with the analysis. The analysis of the Spitzer data will enable us to identify the protoclusters and pre-protocluster cores in our sample and to derive the properties of these earliest stages of massive star formation.

Spitzer Space Telescope - General Observer Proposal #50044

The MIPSGAL Red Point Source Survey

Principal Investigator: Kathleen Kraemer
Institution: Air Force Research Laboratory

Technical Contact: Kathleen Kraemer, Air Force Research Laboratory

Co-Investigators:
Sachin Shenoy, Spitzer Science Center
Thomas Kuchar, Boston College
Donald Mizuno, Boston College
Sean Carey, Spitzer Science Center
Steve Price, Air Force Research Laboratory
James Ingalls, Spitzer Science Center
Remy Indebetouw, University of Virginia
Francine Marleau, Spitzer Science Center
Michael Werner, Jet Propulsion Laboratory

Science Category: young stellar objects
Observing Modes: IrsStare
Hours Approved: 9.8

Abstract:
We propose to obtain IRS spectra for a set of very red point sources from the MIPS survey of the inner Galactic plane. These objects are among the reddest [8]-[24] sources in the surveyed region. They are significantly redder than the general population of young stellar objects but are typically too bright to be background galaxies. On infrared color-color diagrams, they do not correspond to any previously known population either in the Milky Way or the Magellanic Clouds. The infrared spectra that only Spitzer's IRS can provide for these very red objects will enable us to decode their anomalous colors, characterize their properties such as grain types and size distributions, temperatures, and radiation fields, and, ultimately, determine their identity.

Spitzer Space Telescope - General Observer Proposal #20119

The Darkest Cloud: An IRAC/MIPS survey of the Pipe Nebula

Principal Investigator: Charles Lada
Institution: Harvard-Smithsonian Center for Astrophysics

Technical Contact: Charles Lada, Harvard-CfA

Co-Investigators:
Joao Alves, European Southern Observatory
Marco Lombardi, European Southern Observatory
August Muench, Harvard-Smithsonian Center for Astrophysics

Science Category: young stellar objects
Observing Modes: IracMap MipsPhot MipsScan
Hours Approved: 106.5

Abstract:
We propose to use Spitzer to perform an IRAC/MIPS imaging survey of the Pipe Nebula, the massive dark cloud complex which is nearest the Sun. Lacking the most obvious signposts of star formation, such as HII regions, reflection nebulae, etc., this cloud appears to be a prime and rare example of a massive molecular cloud in a very early stage of evolutionary development. The primary goal of this survey will be to obtain a complete census of protostellar and star formation activity in this extremely young cloud. This data will be combined with the results of a major observational program we have been conducting to map and measure the structure of the entire cloud complex, including all its dense cores, using deep near-infrared extinction observations obtained from the ground. The synthesis of the extinction and Spitzer data will used to construct a detailed empirical picture of the earliest stages of dense core and protostellar evolution. As a secondary goal we also intend to use the proposed Spitzer observations, in conjunction with the near-infrared observations, to constrain the 1-8 micron extinction law in the cloud and to measure the extinction in the most opaque (Av > 40 mag) dense cores, which cannot be penetrated by ground-based observations alone.

Spitzer Space Telescope - General Observer Proposal #30033

The nature and evolutionary status of protostars in clustered environments

Principal Investigator: Charles Lada
Institution: Harvard-Smithsonian Center for Astrophysics

Technical Contact: Charles Lada, Harvard-CfA

Co-Investigators:
August Muench, Smithsonian Astrophysical Observatory
Paula S. Teixeira, Smithsonian Astrophysical Observatory
Kevin Luhman, The Pennsylvania State University
Kenneth Wood, University of St Andrews
Erick Young, University of Arizona

Science Category: young stellar objects
Observing Modes: IrsMap
Hours Approved: 43.0

Abstract:
We propose to obtain Spitzer IRS spectra of a statistically significant sample of ~50 protostellar sources that we have identified in previous GTO observations of the NGC 2264 and IC 348 clusters. We intend to measure and characterize the mid-infrared spectral features between 5-40 micron of these sources to develop a more refined empirical classification and evolutionary sequence for high and low mass protostellar objects than otherwise possible using broad-band infrared SEDs alone. We intend to employ detailed radiative transfer models to fit the entire SEDs, including the IRS observations, in order to derive constraints for the basic physical properties of the protostars in our sample, including the luminosities of the central sources and the masses, density structures, and infall rates that characterize their envelopes. We intend to investigate how the spectral properties of protostars depend on their mass and star forming environment in order to develop a more complete picture of protostellar evolution. The proposed Spitzer IRS observations will enable us to place the comparison of the individual and collective protostellar characteristics on a firm quantitative footing.

Spitzer Space Telescope - General Observer Proposal #50532

Disentangling PDRs and outflows of embedded solar mass protostars

Principal Investigator: Fred Lahuis
Institution: Leiden Observatory, SRON Groningen

Technical Contact: Fred Lahuis, Leiden Observatory, SRON Groningen

Co-Investigators:
Geoffrey Blake, Division of GPS, Caltech
Jes Joergensen, Argelander Institut fur Astronomie
Ewine van Dishoeck, Leiden Observatory
Tim van Kempen, Leiden Observatory

Science Category: young stellar objects
Observing Modes: IrsStare
Hours Approved: 10.7

Abstract:
Understanding the nature of deeply embedded solar mass protostars is one of the interesting challenges in the study or low-mass star formation. Highly energetic processes, such as strong irradiation and outflows, are likely directly related to the ongoing accretion onto the central growing protostar. UV radiation is known to play a role in the envelopes around more massive young stellar objects (YSOs) and in the physics and chemistry of disks around more evolved pre-main sequence stars. Because the UV radiation does not penetrate far through the envelope, very little is known about the impact of UV radiation in these early stages of low-mass YSOs and whether they have associated photon-dominated regions (PDRs). Mid-infrared Spitzer observations of atomic fine-structure lines, molecular hydrogen and water at both small and large spatial scales can be used to place direct constraints on the processes associated with accretion, PDR and shock excitation. We here propose to obtain deep IRS high resolution observations of a sample of seven embedded protostars which show either extended PDR type emission lines or water emission in existing lower S/N IRS spectra. These observations will address whether the extended line emission is uniquely related to PDRs and if so, whether the origin of the UV radiation producing the PDR has its origin in the accretion from the central star - or whether it is related to outflow driven shocks.

Spitzer Space Telescope - General Observer Proposal #3290

Chemical Evolution of Dust Grains in Prestellar Cores

Principal Investigator: William Langer
Institution: JPL

Technical Contact: William Langer, JPL

Co-Investigators:
Thangasamy Velusamy, JPL
Karen Willacy, JPL

Science Category: young stellar objects
Observing Modes: IracMap IrsStare MipsPhot
Hours Approved: 19.5

Abstract:
The primary goal of this proposal is to trace the ice and gas evolution in evolving prestellar cores and thereby understand their dust and chemical evolution. In these cold (10K) cores we see evidence for severe depletion of gas molecules in the highest density regions, in agreement with models that predict a steady accumulation of grain mantles in dense cores. We propose to obtain absorption spectral data of molecular ices in a few prestellar and protostellar cores using 2MASS stars as background targets. We will compare the ice column densities along representative lines of sight for which we have dust column density measurements through the cores from the extinction data. For one source, B68, there are a sufficient number of background stars to determine the radial distribution of ice material. We will use these Spitzer Space Telescope observations to validate and refine our protostellar chemical models, which in turn will enable us to understand more about the pathways to the gas, gas-grain processes that lead to the formation of simple molecules and complex biogenic species in the interstellar medium. We seek twenty hours of Spitzer IRS time to collect spectral data in six representative prestellar cores, at varying evolutionary status, which are currently subjected to intense observing at all wavelengths and theoretical modeling.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #116

Spectral Mapping of NGC 1333

Principal Investigator: Charles Lawrence
Institution: JPL

Technical Contact: Nick Gautier, JPL

Science Category: young stellar objects
Observing Modes: IrsMap
Hours Approved: 12.9

Abstract:
We will carry out a spectral mapping of the central 17x25 arcmin of NGC 1333, a galactic molecular cloud rich in dense gas, very young stars, and outflows from low mass stars. Our primary goal is to map the spatial distribution of H2 rotational emission at 17 and 28 microns associated with the outflows. Additional goals are a study of the ice features associated with the embedded YSOs, and the identification of extended dust emission features. The results will be compared with existing millimeterwave CO maps and images of shocked gas from optical and near-IR wavelengths.

Spitzer Space Telescope - General Observer Proposal #30516

Outflows, Cavities, and Evolution

Principal Investigator: Leslie Looney
Institution: Univ of Illinois at Urbana-Champaign

Technical Contact: Leslie Looney, Univ of Illinois at Urbana-Champaign

Co-Investigators:
John Tobin, UIUC
Sandor Van Wassenhove, UIUC
Woojin Kwon, UIUC

Science Category: young stellar objects
Observing Modes: IracMap
Hours Approved: 8.9

Abstract:
Class 0 low-mass protostars are heavily embedded, very young sources; however, the powerful molecular outflows associated with low-mass star formation carve out a cavity in the circumstellar envelope. In the cavity, light from the otherwise opaque newborn star is scattered off dust into the field of view; this scattered light is detectable in the IRAC wavelengths but usually only with very deep imaging. We propose to deeply image 11 known Class 0 protostars with IRAC to reveal the scattered light from the outflow cavity. We will compare these observations, along with archive data, to radiative transfer models to constrain the physical parameters of the source and cavity, as well as determine why some cavities are detected in shallow surveys while others require very deep imaging. This proposal will peer into the depths of star formation and provide an important dataset for the study of low-mass star formation in the infrared.

Spitzer Space Telescope - General Observer Proposal #40650

An Evolutionary Survey of Massive YSOs

Principal Investigator: Leslie Looney
Institution: University of Illinois

Technical Contact: Leslie Looney, University of Illinois

Co-Investigators:
You-Hua Chu, University of Illinois
Robert Gruendl, University of Illinois
Bernhard Brandl, Sterrewacht Leiden
Rosie Chen, University of Illinois
Katherine Lee, University of Illinois
Geoff Blake, CalTech
Wolfgang Brandner, University of California, Los Angeles

Science Category: young stellar objects
Observing Modes: IrsStare
Hours Approved: 96.0

Abstract:
Galactic massive star formation regions can be studied with high resolution, but the large angular size, confusion along the line-of-sight, and heavy extinction in the Galactic plane make it difficult to determine the relationship among different stellar and gaseous components. However, new Spitzer Space Telescope observations have revealed 244 high-mass YSO candidates in the Large Magellanic Cloud (LMC) (Gruendl et al. 2007, in preparation). The selection of the sources is crucial in optimizing the science to Spitzer observing time. This new sample of massive protostars, coupled with the benefits of the LMC, such as known distance (50 kpc), nearly face-on orientation, and low foreground extinction, mitigates many observational difficulties. We propose to utilize our unique database of massive protostar candidates in the LMC to probe the evolutionary sequence of massive protostars with the IRS spectrometer. Our sample of 244 YSO candidates sample different environments (e.g. in clusters or isolated; embedded in molecular gas or not). In our large sample, we will compile an evolutionary sequence of sources that will start with ices and silicates, move toward less ices and more gas-phase absorption, then finally the gas-phase absorption disappears as, effectively, an HII region is born. In addition, these data are a singular probe of the organic chemistry occurring near massive stars that will help develop a consistent picture of massive star formation.

Spitzer Space Telescope - General Observer Proposal #40844

Going Long: a 70 micron Survey of Nearby Young Stellar Objects

Principal Investigator: Caer-Eve McCabe
Institution: Jet Propulsion Laboratory

Technical Contact: Caer-Eve McCabe, Jet Propulsion Laboratory

Co-Investigators:
Karl Stapelfeldt, Jet Propulsion Laboratory
Deborah Padgett, Spitzer Science Center
Luisa Rebull, Spitzer Science Center
Francois Menard, Observatoire de Grenoble
Paul Harvey, University of Texas
Neal Evans, Jr., University of Texas
Bruno Merin, ESA

Science Category: young stellar objects
Observing Modes: MipsPhot
Hours Approved: 26.8

Abstract:
The Spitzer Space Telescope is making major contributions to our understanding of the structure, composition, thermal state, and evolution, of circumstellar disks around young stars through numerous observing projects. Among the most important of these are large-scale mapping surveys of the nearest molecular clouds, where Spitzer achieves its greatest sensitivity to low mass stars and brown dwarfs, and where it provides its best linear resolution. At wavelengths < 24 microns, the c2d and Taurus Legacy projects have produced datasets that are 2-3 orders of magnitude more sensitive than IRAS or ground-based work. But at 70 microns, a key wavelength that probes disk structure near 10 AU and which is sensitive to a large fraction of the disk luminosity, these surveys have bettered IRAS sensitivity by only a factor of five. We propose to augment the Spitzer Legacy datasets for Taurus and Lupus, two nearby clouds with low cirrus emission, by performing dedicated MIPS 70 micron photometry observations of 113 young stars identified from the shorter wavelength data, and for which no 70 micron source was detected in the existing shallow survey data. These new observations will provide a 5-10x improvement in sensitivity over the existing Legacy data sets, significantly enhancing their value for a wide range of star formation and disk science. The results will be delivered to the SSC Archive in early 2009.

Spitzer Space Telescope - General Observer Proposal #3178

Searching for Proto-clusters in a Quiescent GIant Molecular Cloud: A Survey for Low Mass Stars and Protostars in Maddalena's Cloud

Principal Investigator: Tom Megeath
Institution: Harvard Smithsonian Center for Astrophysics

Technical Contact: Tom Megeath, Harvard, CfA

Co-Investigators:
Matthew Ashby, Smithsonian Astrophysical Observatory
Thomas Wilson, European Southern Observatory

Science Category: young stellar objects
Observing Modes: IracMap MipsScan
Hours Approved: 9.5

Abstract:
We propose an IRAC and MIPS survey toward recently identified dense cores in Maddalena's cloud, a unique, quiescent giant molecular cloud. To date, no sites of star formation have been identified in this 100,000 solar mass cloud; however, our detection of massive (~ 500 solar mass) dense cores suggests that the formation of entire clusters of stars is imminent. At a distance of 2 kpc, it is possible that isolated, low mass pre-main sequence stars and protostars remain undetected this cloud. IRAC and MIPS will be able to detect any T-Tauri star down to the hydrogen burning limit, as well as one solar luminosity protostars too faint to have been detected with MSX and IRAS. We will also observe the cool dust in the dense cores using the MIPS 70 and 160 micron bands. With these data, we can map the dust temperature and column density in the dense cores with twice the angular resolution of our millimeter-wave maps. We will use the dust map to study the density structure of the dense cores and compare the density structure to active cluster forming cores. With this data, we will determine whether low mass star formation has started toward the dense cores, giving us a rare glimpse at what appears to be the first stages of cluster formation.

Spitzer Space Telescope - General Observer Proposal #3656

Star Formation in Isolated Cores: A Solitary Existence?

Principal Investigator: Lee Mundy
Institution: University of Maryland

Technical Contact: Lee Mundy, University of Maryland

Co-Investigators:
Nicholas Chapman, University of Maryland
Lori Allen, Harvard-Smithsonian Center for Astrophysics
Paul Harvey, University of Texas
Leslie Looney, University of Illinois
Shih-Ping Lai, Univeristy of Maryland
Phil Myers, Smithsonian Astrophysical Observatory

Science Category: young stellar objects
Observing Modes: IracMap MipsPhot
Hours Approved: 15.0

Abstract:
The standard theories of star formation address the formation of a single star in isolation. Dark cloud cores are often cited as examples of isolated, individual star formation. Because of the density of these cores, observations to date have not had the sensitivity to really examine the core structure and search for the youngest and lowest mass sub-stellar objects. We propose to observe ten dark cores, five without associated stars and five with an associated star in all four IRAC bands and MIPS 24 micron. In addition, we will combine these observations with deep JHK ground-based imaging. We will observe the youngest sub-stellar objects down to 10 Jupiter masses, map the column density structure via extinction measurements, and image faint extended emission, such as outflows that are indicative of cloud-star interaction. Our overall goal is to test standard star formation theory by identifying the entire stellar and sub-stellar content of the cores and the relation of these objects to the gas and dust distribution.

Spitzer Space Telescope - Directors Discretionary Time Proposal #228

Following the Outburst of V1647 Ori

Principal Investigator: James Muzerolle
Institution: University of Arizona

Technical Contact: James Muzerolle, University of Arizona

Co-Investigators:
Tom Megeath, SAO
Nadya Gorlova, U. Arizona
Erick Young, U. Arizona
George Rieke, U. Arizona

Science Category: young stellar objects
Observing Modes: IracMap IrsStare MipsPhot MipsSed
Hours Approved: 0.5

Abstract:
We propose to obtain follow-up Spitzer observations of V1647 Ori, the outbursting source lighting McNeil's nebula. Our analysis of serendipitous GTO IRAC and MIPS data of this object taken at the peak of the outburst has shown a significant increase of roughly a factor of 15 over pre-outburst levels. We have interpreted this event as an increase in the accretion luminosity of the source. Simple models of an accretion disk plus tenuous envelope can qualitatively explain the observed pre- and post-outburst spectral energy distributions. The accretion activity implied by our results indicate that the outburst may be intermediate between FUor and EXor-type events. Outbursts of either type have never before been followed in the infrared throughout their course. Follow-up observations taken before V1647 Ori fades to its original brightness are critical to understanding the evolution of this phenomenon. Spitzer photometry and spectra will reveal important clues about the structure of the envelope and how it responds to the changing luminosity of the central source, elucidating the role of outbursts in the evolution of young stellar objects.

Spitzer Space Telescope - General Observer Proposal #20155

Probing the embedded molecular jets from Class 0 protostars

Principal Investigator: Brunella Nisini
Institution: INAF-Osservatorio Astronomico di Roma

Technical Contact: Brunella Nisini, INAF-Osservatorio Astronomico di Roma

Co-Investigators:
Christopher J. Davis, Joint Astronomy Centre
Teresa Giannini, INAF-Osservatorio Astronomico di Roma
Michael D. Smith, Armagh Observatory
Alessio Caratti o Garatti, INAF-Osservatorio Astronomico di Roma
Dario Lorenzetti, INAF-Osservatorio Astronomico di Roma

Science Category: young stellar objects
Observing Modes: IrsStare
Hours Approved: 6.7

Abstract:
Flows of matter from young and heavily embedded ''Class 0'' protostars are often observed only at millimeter wavelengths in the form of collimated molecular jets. An important open debate is whether such jets represent the cold external layer of an embedded atomic jet, or whether the jet itself is intrinsically composed of only molecular gas under low excitation conditions. The aim of this proposal is to obtain insight into the composition and excitation of such jets through IRS observations of mid-IR lines, which are unique tracers of the warm embedded gas components. The immediate objectives will be: 1) to detect the atomic/ionic component associated with Class 0 molecular jets; 2) to derive detailed physical quantities (temperature, density, ionization fraction) to be compared with models for acceleration and propagation of jets, models which have so far only been tested on more evolved CTT stars; 3) to determine if such jets have sufficient momentum and energy to sustain the swept up gas seen further out in the form of near-IR bow shocks. To this aim, a sample of four well-known Class 0 jets have been selected for which near-IR, millimeter and ISO observations are already available. This will ensure a thorough comparison of the different jet excitation components which should ultimately be explained in a unified flow model.

Spitzer Space Telescope - General Observer Proposal #3315

Emission from H2, PAHs, and Warm Dust in Proto-stellar Jets

Principal Investigator: Alberto Noriega-Crespo
Institution: Spitzer Science Center

Technical Contact: Alberto Noriega-Crespo, Spitzer Science Center

Co-Investigators:
William Latter, Spitzer Science Center
Jochen Eisloffel, Tautenburg Observatory
Alejandro Raga, Instituto de Ciencias Nucleares
Karl Stapelfeldt, Jet Propulsion Laboratory
Francine Marleau, Spitzer Science Center
Patrick Morris, Spitzer Science Center
Sean Carey, Spitzer Science Center

Science Category: young stellar objects
Observing Modes: IracMap IrsStare MipsScan
Hours Approved: 18.0

Abstract:
Most of the observational work on the properties of young stellar outflows in the mid-infrared has been done for relatively bright objects. The new images obtained by Spitzer of the young stellar outflow HH 46/47, demonstrate what higher sensitivity and spatial resolution can do with optically fainter objects at longer wavelengths. We propose an IRAC/MIPS imaging and IRS spectral mapping survey of 7 other well-studied Herbig-Haro flows. The targets are selected to span a range of central star luminosities, ambient medium densities, and flow characteristics. Our goal is to detect the full extent of their outflow cavities in deep IRAC images, and their chemical make up using IRS spectra. The mid-infrared morphology of the outflows will be compared to existing optical and near-infrared images of jets and bowshocks, and to maps of high velocity molecular gas. With geometry of the outflow cavities defined by the mid-infrared images, we can gain the first clear understanding of where ambient cloud material is being entrained by the collimated flow, and further constrain the dynamical models of proto-stellar flows.

Spitzer Space Telescope - General Observer Proposal #3584

A Spitzer Imaging Survey of the Entire Taurus Molecular Cloud

Principal Investigator: Deborah Padgett
Institution: California Institute of Technology

Technical Contact: Deborah Padgett, California Institute of Technology

Co-Investigators:
Alberto Noreiga-Crespo, Spitzer Science Center
Lori Allen, SAO
Jocelyn Keene, Jet Propulsion Laboratory
Neal Evans, University of Texas
Phil Myers, CFA/Harvard
Sean Carey, Spitzer Science Center
Tim Brooke, Caltech
Sebastian Wolf, Max Planck Institute fur Astronomie
Luisa Rebull, Spitzer Science Center
Catherine Dougados, Observatoire de Grenoble
Steve Strom, NOAO
Paul Harvey, University of Texas
Marc Audard, Columbia University
Lynne Hillenbrand, Caltech
Carol Lonsdale, IPAC
Bill Latter, Spitzer Science Center
Jerome Bouvier, Observatoire de Grenoble
Nicolas Grosso, Observatoire de Grenoble
David Shupe, Spitzer Science Center
Steve Skinner, CASA
Karl Stapelfeldt, Jet Propulsion Laboratory
Dean Hines, Space Science Institute
Francois Menard, Observertoire de Grenoble
Manuel Guedel, University of Zurich

Science Category: young stellar objects
Observing Modes: IracMap MipsScan
Hours Approved: 134.4

Abstract:
The star-forming clouds nearest to our Sun are located 140 pc away in Taurus. Lacking young stellar clusters and luminous OB stars, Taurus hosts a distributed mode of star formation that has proven particularly amenable to observational and theoretical study. Yet despite its importance to the past two decades of star formation research, only fragments of the Taurus clouds are currently planned for mapping with the Spitzer Space Telescope. We propose to make a comprehensive, unbiased map of the TMC using MIPS and IRAC, covering an area of 28 square degrees. Achieving sensitivities 20 times better than ISOCAM at 8 microns, and 200 times better than IRAS at 24 microns, these maps will reveal the lowest luminosity members of the young stellar population: collapsing protostars, young substellar objects, and edge-on disks. Due to the importance of this dataset in establishing new objects for followup with Spitzer and HST, we will waive our proprietary rights to the data and make the images and source catalogs available to the community upon completion of the survey. This survey will be a central and crucial part of a multiwavelength study of the Taurus cloud complex that we are already conducting using XMM and CFHT. The 5 - 7 photometry data points we will obtain from Spitzer will allow us to characterize the circumstellar environment of each object, and, in conjunction with NIR photometry, construct a complete luminosity function for the cloud members that will place constraints on the initial mass function.

Spitzer Space Telescope - General Observer Proposal #50584

Pre-Main Sequence Stars in the Greater Taurus Ecosystem

Principal Investigator: Deborah Padgett
Institution: California Institute of Technology

Technical Contact: Deborah Padgett, California Institute of Technology

Co-Investigators:
Luisa Rebull, Spitzer Science Center
Jill Knapp, Princeton University
Cathy Slesnick, California Institute of Technology
Karl Stapelfeldt, Jet Propulsion Laboratory
Sean Carey, Spitzer Science Center
Alberto Noriega-Crespo, Spitzer Science Center
Lynne Hillenbrand, California Institute of Technology
Manuel Guedel, Paul Scherrer Institut
Caer McCabe, Jet Propulsion Laboratory
Marc Audard, University of Geneva
Susan Terebey, California State University at Los Angeles
Sylvain Guieu, Spitzer Science Center
Sebastian Wolf, MPIA Heidelberg

Science Category: young stellar objects
Observing Modes: IracMap MipsPhot
Hours Approved: 17.4

Abstract:
Weak-line and post-T Tauri stars may represent an important evolutionary link in the story of planet formation. However, most lists of nearby WTTS are based on X-ray brightness and strong lithium absorption lines, indicators of youth which often cannot distinguish between pre-main sequence and Pleiades-age (100 Myr) stars. New optical surveys of the Taurus star-forming region have used the gravity-sensitive sodium lines to identify young pre-main sequence stars. Most of these objects lie outside the existing area of the Taurus Spitzer surveys. For the subset within our maps, 1/3 have excess within the Spitzer bands, validating this selection technique for young stars. We propose to obtain pointed Spitzer IRAC and MIPS photometry of these stars, which appear to form part of the "Greater Taurus Ecosystem": an extended halo of youthful stars associated with, but outside, the star-forming molecular clouds. Our goals are to measure the frequency, fractional luminosity, and spatial distribution of disks within this extended young stellar population, and to identify rare transition disks among these post-T Tauri star candidates. The results will build a more complete picture of the late stages of disk evolution around low mass stars, and will be significant additions to the Spitzer science legacy for the Taurus region.

Spitzer Space Telescope - Theoretical Research Proposal #40203

Simulating 3D disks with planets and central clearings

Principal Investigator: Alice Quillen
Institution: University of Rochester

Technical Contact: Alice Quillen, University of Rochester

Co-Investigators:
Richard Edgar, University of Rochester
Adam Frank, University of Rochester
Jaehong Park, University of Rochester
Peggy Varniere, Observatoire de Grenoble

Science Category: young stellar objects
Dollars Approved: 39510.0

Abstract:
3-dimensional hydrodynamic numerical experiments of disks harboring planets will be carried out for the purpose of exploring the planet/disk interaction scenario to account for the central clearings and disk walls in transition disks. Transitional disks are young, 1-3 Myr old stars hosting disks with central clearings. Dozens of these disks have been discovered with Spitzer observations and strong constraints on the radial and vertical dust distribution of these disks have been made from IRS spectra and radiative transfer modeling. However because of the estimated edge wall thickness (h/r~1/5) relevant models relating disk structure to dynamical models require computationally challenging 3D simulations and so are lacking. We propose to address this problem by carrying out 3D AMR hydro simulations to examine the 3D structure of simulated disk edges, measure the flow field with azimuth and height, determine if and when sufficiently high dust deficits with the clearing can be achieved, and explore the role of dust segregation in the disk edge. Our study will definitively test the planet/disk scenario accounting for the transitional disks. Should the scenario succeed, we will place constraints on the planet masses residing in transition disks and their disk properties.

Spitzer Space Telescope - General Observer Proposal #40230

Spectroscopic Study of Massive YSO Candidates in the Galactic Center

Principal Investigator: Solange Ramirez
Institution: California Institute of Technology

Technical Contact: Solange Ramirez, California Institute of Technology

Co-Investigators:
Angela Cotera, SETI Institute
Howard Smith, Center for Astrophysics, Harvard University
Kris Sellgren, The Ohio State University
Susan Stolovy, Spitzer Science Center, Caltech
Richard Arendt, CRESST/UMBC/GSFC
Thomas Robitaille, University of St. Andrews, UK
Mathias Schultheis, Observatoire de Besancon, France

Science Category: young stellar objects
Observing Modes: IrsMap IrsStare
Hours Approved: 56.3

Abstract:
The coexistence between extreme environmental conditions (high density, turbulence, magnetic field strengths, and tidal shear) and young massive stars in the Galactic Center has led to one unsolved question: how do stars form in a region which appears to be quite hostile to star birth? Within the central 200 pc, almost all stages of the stellar life cycle have been identified: molecular clouds, HII regions (including compact HII regions), young massive stars, supernova remnants, old red giant and AGB stars. An important class of objects which has yet to be conclusively established and therefore has not been studied, is massive young stellar objects (YSOs). One hundred and seven (107) massive YSO candidates have been identified by Spitzer/IRAC observations in the central 2.0 by 1.4 degrees (280 x 210 pc) of our Galaxy. We propose to observe this sample using the IRS to determine the evolutionary status of these objects. The presence or absence of forbidden emission lines, ice features, and molecular absorptions will determine if these objects are indeed massive YSOs or evolved AGB stars (YSOs and AGB stars have similar IRAC colors). The IRS spectra will be used to constrain the models of the YSOs,which will provide estimates of their stellar masses. The main goal of the study is to determine the distribution of YSOs in the Galactic Center, their correlation with known clusters, ionized gas, molecular gas and photodissociation regions, and their mass distribution. These results will characterize a stellar population that has been undetected before in the central regions of our Galaxy and provide unique knowledge about the early stages of star formation processes occurring in the Galactic Center.

Spitzer Space Telescope - General Observer Proposal #3137

Spectroscopy of Spitzer-discovered Protostars in the Elephant Trunk Nebula

Principal Investigator: William Reach
Institution: Caltech

Technical Contact: William Reach, Caltech

Co-Investigators:
Jeonghee Rho, Caltech
Sean Carey, Caltech
Patrick Morris, Caltech
Adwin Boogert, Caltech
David Ciardi, Caltech

Science Category: young stellar objects
Observing Modes: IrsStare
Hours Approved: 9.1

Abstract:
We propose to obtain spectra of protostellar candidates discovered in the early Spitzer observation of IC 1396N. No protostars were known or suspected in the globule before the Spitzer observations, and the properties of such objects are not known. The IRS observations were designed with sufficient signal-to-noise to detect absorption features due to silicates and ices. The shape of the spectral energy distribution and the depth of the silicate feature will be used to determine the ratio of stellar core to envelope mass and determine the evolutionary state of these new objects. This is a unique sample having a range of suspected evolutionary states all located in the same globule.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50596

Dynamic YSOs: Exploring the time domain in disks and protostars

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: James Muzerolle, University of Arizona

Co-Investigators:
Lori Allen, Harvard-Smithsonian Center for Astrophysics
Zoltan Balog, Steward Observatory
Nuria Calvet, University of Michigan
Paola D'Alessio, Instituto de Astronomia UNAM
Catherine Espaillat, University of Michigan
Kevin Flaherty, Steward Observatory
Elise Furlan, UCLA/NAI
S. Thomas Megeath, University of Toledo
August Muench, Harvard-Smithsonian Center for Astrophysics
Peter Plavchan, IPAC
Dan Watson, University of Rochester

Science Category: young stellar objects
Observing Modes: IracMap IrsStare MipsPhot
Hours Approved: 15.1

Abstract:
We propose to obtain multi-epoch IRAC mapping and IRS spectroscopy of a number of variable young stellar objects (YSOs) in order to constrain the time dependence of their mid-infrared emission. Preliminary Spitzer results indicate a surprising degree of variability in the majority of YSOs surveyed to date. The observed variations exhibit a wide range of timescales (hours to years) and amplitudes (10-100%), and some show completely unexpected wavelength dependences. The variable objects span a range of evolutionary states, from embedded protostars with infalling envelopes to T Tauri stars with evolved circumstellar disks. Some of the strongest variables appear to be associated with disks whose structure may be highly modified by the presence of companions and ongoing planet formation. With high-cadence IRAC imaging of a young cluster, we will examine changes in the structure and accretion activity of the innermost regions of disks around both protostars and accreting T Tauri stars.
High-cadence IRS spectroscopy of some of the most striking variable YSOs will help to isolate and characterize the source(s) of the variability. These data will provide an essential tool for understanding the dynamic processes involved in protostellar collapse, accretion, and planet formation.

Spitzer Space Telescope - General Observer Proposal #40648

Inner disk activity in T Tauri stars

Principal Investigator: Sonali Shukla
Institution: Vanderbilt University

Technical Contact: Sonali Shukla, Vanderbilt University

Co-Investigators:
David Weintraub, Vanderbilt University
Patrick Lowrance, Spitzer Science Center

Science Category: young stellar objects
Observing Modes: IrsStare
Hours Approved: 2.8

Abstract:
In order to increase our current knowledge of the evolutionary process of young stellar objects, we propose to conduct a careful study that correlates Spitzer observations with Chandra spectral data of young solar analogs. Although very few young solar analogs are bright enough in X-rays for Chandra to obtain high resolution spectra, we have identified a sample of nine stars already in the Chandra archive, observed with the high resolution spectrometer on-board Chandra. Our sample consists of both classical, weak-lined, and post-T Tauri stars as well as a young main sequence star. Archival IRS spectra exist in the Spitzer archives for five of these stars. We request time to observe the remaining four stars with Spitzer IRS. These observations are crucial to the sample since they include the post T Tauri and main sequence star that complete the sample across a full range of evolutionary stages. This study will be the first direct comparison of mid-infrared spectral features with high-resolution X-ray spectral signatures of young stellar objects. As a complement to this observing proposal, a Cycle 4 archival proposal has been submitted to analyze the Spitzer IRS archival data. Using Spitzer IRS to study spectral features and overall shape of the SED from 5 -40 microns in conjunction with high resolution spectroscopy from Chandra, we will correlate mid-infrared and X-ray features in different classes of YSOs to determine an evolutionary sequence in terms of accretion from inner and outer regions of a circumstellar disk. The evolution and overall lifetimes of such circumstellar disks is crucial to understanding the likelihood of planet formation around solar-type stars.

Spitzer Space Telescope - General Observer Proposal #20452

Spitzer Survey of Triggered Star Formation in Carina: HH666 Extension

Principal Investigator: Nathan Smith
Institution: University of Colorado

Technical Contact: Nathan Smith, University of Colorado

Co-Investigators:
Ed Churchwell, University of Wisconsin

Science Category: young stellar objects
Observing Modes: IracMap
Hours Approved: 1.3

Abstract:
The Carina Nebula is arguably the best available laboratory for studying active star formation threatened by feedback from extremely massive stars, including several of the most luminous O-type stars known, WR stars, and Eta Carinae. It is close enough that we can study the low-mass stellar population, we can detect protoplanetary disks and jets, and we can spatially resolve individual stars, star-forming cores, and ultracompact HII regions. Thus, we can identify the dominant physical processes at work to gain insight to the detailed processes occurring in extragalactic starbursts. The main long-term goal is to determine if detailed models derived from study of Orion and Taurus can be applied in more extreme regions like Carina, or in what ways they need to be modified. During our Cycle 1 IRAC survey of the Carina Nebula, one of our primary targets was not observed due to position angle constraints in a large mosaic. The present proposal asks for a small amount of additional time (1.3 hr) to include this target in the survey and properly complete the Cycle 1 program. Thus, the text for much of this proposal is similar to the Cycle 1 proposal. This region is a vivid example of second generation (possibly triggered) star formation, containing compact IR sources, a parsec scale Herbig-Haro jet, and a giant dust pillar that points toward Eta Carinae.

Spitzer Space Telescope - General Observer Proposal #50354

The GGD30 YSO

Principal Investigator: Robert Smith
Institution: Australian Defence Force Academy, New South Wales

Technical Contact: Robert Smith, Australian Defence Force Academy, NSW

Co-Investigators:
Christopher Wright, Australian Defence Force Academy, New South Wales

Science Category: young stellar objects
Observing Modes: IrsStare
Hours Approved: 1.4

Abstract:
Our previous observations suggest that an infrared source within the GGD30 nebula is an example of an object in the earliest stages of the star formation process. Optical spectoscopy has revealed a Herbig-Haro Object associated with this source and radio interferometry has revealed an extended 3 mm continuum source at the same position as the infrared source. In addition, a Spitzer IRAC 8 micron image from the GLIMPSE Legacy program shows what appears to be the protostellar envelope of this source. We are requesting Spitzer IRS time to obtain a spectrum of this source and its envelope from 5 to 38 microns with a combination of the high and low resolution modules. Our immediate goals are to study the broad solid state dust features and to look for shock excited emission linesclose to the source. In the longer term we plan radiative transfer modeling to try and determine whether there is a disk close to the source and, provided we can obtain sufficient millimeter observations of the molecular content of the envelope, chemical modelling should the age of the envelope to be constrained.

Spitzer Space Telescope - Directors Discretionary Time Proposal #470

Variability of protostars in IC 1396

Principal Investigator: Tom Soifer
Institution: SSC

Technical Contact: John Stauffer, SSC

Science Category: young stellar objects
Observing Modes: IracMap
Hours Approved: 15.0

Abstract:
Temporal variations in the mid-infrared emission from class 0-III protostars can provide information on t he rate of mass transfer from the envelope to accretion disk. Variations in the mass transfer rate can have profound implications on the lifetime of a particular protostellar phase. Variability can also determine rotational coupling between protostar and disk. There have been few attempts to detect mid-infrared variability in young stellar objects. We propose monitoring of 16 young stellar objects in IC 1396 over a period of 14 days to measure if any variability is present. Variability on timescales of days, hours and minutes will be measured. These observations will be compared with archival observations of IC 1396 to look for fluctuations over longer time periods.

Spitzer Space Telescope - Directors Discretionary Time Proposal #235

Young Stars in IC 2118

Principal Investigator: Tim Spuck
Institution: Oil City Area Sr. High School

Technical Contact: Luisa Rebull, SSC

Co-Investigators:
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Luisa Rebull, Spitzer Science Center

Science Category: young stellar objects
Observing Modes: IracMap MipsScan
Hours Approved: 1.0

Abstract:
IC 2118, the Witch Head Nebula (~210 parsecs), is region forming stars located near the supergiant star Rigel in the constellation Orion. Kun et al. (2004, A&A, 418, 89) have determined that IC 2118 is on the near side of the Orion-Eridanus Super Bubble and that stellar winds from the Orion OB1 association may be triggering new star formation in the nebula. We propose using IRAC and MIPS to reexamine a small dense region of this nebula where Kun et al. have spectroscopically identified three 2MASS sources as T Tauri stars embedded in the cloud. Previous all-sky surveys, including both IRAS and 2MASS, have included this region, but not to the resolution that Spitzer can provide, and there are few studies of this particular region in the literature. Our team proposes to use IRAC and MIPS observations to (1) investigate star formation, (2) look for likely cluster member stars with infrared excesses, and characterize this young star population by obtaining their colors and therefore estimates of masses and ages, (3) study the distribution of stars, their relationship to the ISM, and the possibilities of triggered star formation, (4) compare the young star population, distribution, and age to other similar sites of star formation, e.g., IC 1396 and (5) produce a dramatic image of the interstellar medium in the region surrounding IC 2118. Since this region is in the Orion constellation near the bright star Rigel, it provides additional appeal to students and the general public.

Spitzer Space Telescope - General Observer Proposal #30765

Infrared Properties of Edge-on Young Stellar Object Disks

Principal Investigator: Karl Stapelfeldt
Institution: Jet Propulsion Laboratory

Technical Contact: Karl Stapelfeldt, Jet Propulsion Laboratory

Co-Investigators:
Caer-Eve McCabe, Jet Propulsion Laboratory
Klaus Pontoppidan, California Institute of Technology
Francois Menard, Observatoire de Grenoble
Deborah Padgett, Spitzer Science Center, Caltech

Science Category: young stellar objects
Observing Modes: IracMap IrsMap IrsStare MipsPhot
Hours Approved: 11.5

Abstract:
Young, edge-on circumstellar disks are uniquely valuable laboratories for the study of planet formation. In these objects, the central star is occulted from direct view, significant stellar PSF artifacts are absent, and the disk is clearly seen as a central dust lane flanked by faint bands of reflected light. The detailed morphology of these nebulae and its variation with wavelength provides crucial information not availble for other young star disks. The disk inclination, density structure, and dust grain properties can be quantitatively constrained by fitting Monte Carlo scattered light models to high resolution images. While edge-on disks are among the best-understood disks in 2-D images, their spectral energy distributions are still poorly characterized and modeled. Very high extinctions and small projected emission regions render the typical edge-on disk extremely faint in the mid- and far- infrared. Infrared measurements are crucial for understanding the inner disk properties, for defining the wavelength where the SED transitions from scattered light to thermal emission, and for diagnosing the presence of large dust grains. We are currently carrying out a multiwavelength Hubble Space Telescope Cycle 14 imaging program studying 15 edge-on disks. A review of the Spitzer ROC shows that adequate MIPS and IRAC measurements already exist for the majority of the targets, but most of them have yet to be observed with IRS. We propose 11.5 hours of Spitzer observations to complete the infrared dataset for the known edge-on disks, primariliy IRS low-resolution spectroscopy, but also cleaning up the MIPS and IRAC results in a few cases. In combination with existing data, the results will provide a complete database of infrared SEDs and high spatial resolution optical/near-IR images for known edge-on disks. The resulting dataset will be a unique resource for modeling work on disk structure and dust grain evolution.

Spitzer Space Telescope - Directors Discretionary Time Proposal #497

Time Series Photometry of the Youngest Stars - MIPS24 Photometry for IC1396A

Principal Investigator: John Stauffer
Institution: Spitzer Science Center

Technical Contact: Luisa Rebull, SSC

Co-Investigators:
Michael Werner, JPL
Lynne Hillenbrand, Caltech
Sean Carey, SSC
Luisa Rebull, SSC
Lee Hartmann, U. Michigan
Maria Morales, LAEFF

Science Category: young stellar objects
Observing Modes: IracMap MipsPhot
Hours Approved: 3.6

Abstract:
We have recently obtained IRAC time-series photometry of the embedded, very young cluster of young stellar objects (YSOs) in the Elephant's Trunk Nebula (a.k.a. IC1396A). About 20% of the YSOs, including about half of the Class I stars, showed relatively large amplitude (> 0.1 mag) variability with characteristic timescales of 4 to 15 days, and with very little difference in light curve shape and amplitude between 3.6 and 8 microns. The most plausible physical model for these variations is that we are seeing these stars primarilyin scattered light all the way out to 8 microns, and that the sources of the variability are hot spots (from accretion flows) on the surfaces of these stars. In order to place further constraints on models for these stars, we propose to obtain MIPS24 photometric observations of the 5'x5' "head" of the IC1396A star-forming globule at sixteen epochs, about twice per day, during a single MIPS campaign. We will also obtain a small amount of new IRAC time-series photometry in an adjacent campaign in order to place the MIPS photometry in better context with the existing IRAC light curves obtained in February 2008. The entire set of observations requires 3.6 hours of observing time.

Spitzer Space Telescope - Directors Discretionary Time Proposal #224

Spitzer Space Telescope Observations of an Accretion Outburst of a New EXOR

Principal Investigator: Guy Stringfellow
Institution: University of Colorado

Technical Contact: Guy Stringfellow, University of Colorado

Science Category: young stellar objects
Observing Modes: IracMap IrsStare
Hours Approved: 3.2

Abstract:
EXORs, named after the prototype EX Lup, are a very small subclass of classical T Tauri stars (CTTSs) which experience rather major optical outbursts. Outbursts of the EXORs result from an enhanced accretion rate from their circumstellar disk, and are intermediate between the long lived and more energetic FU Ori type outbursts (FUORs) and the more modest accretion variability of the CTTSs. The accretional energy liberated results in a brightening of 3--5 magnitudes in the optical alone. Outbursts play a major role in modifying the circumstellar environment, and initiate the formation of winds, jets, and HH objects, and contributes to dispersal of the disk. EXOR and FUOR outbursts frequently occur over disk-accretion lifetimes in YSOs, though rarely observed; we have observing programs to rectify this. The large physical changes in the circumstellar environment during such outbursts likely influence the formation and evolution of giant planets and brown dwarfs. On 9 Feb 2004 a previously unknown EXOR was announced (IAUC 8284). Archival images indicate that this new EXOR (IRAS 05436-0007) had undergone repeated outbursts over the last few decades, and its current outburst has been ongoing for ~3 months. IRAS 05436-0007 differs from most EXORs as it is embedded in a dark cloud (though now visible) and illuminates a (variable) nebula. There are only ~12 previously confirmed members of the EXOR class, and discovery of new events, particularly one that emerges from an embedded state, are very rare. The opportunity exists to obtain crucial observations during the present outburst as the SST visibility window remains open thru 29 March. We have begun intensive ground-based optical and near-IR supporting observations on 10 Feb, and these will continue. These observations will greatly assist in determining the outburst physics, and the response of the disk and circumstellar environment to the infusion of the large amount of energy emitted by the accretion event.

Spitzer Space Telescope - General Observer Proposal #30601

Ices in envelopes around intermediate-mass young stellar objects

Principal Investigator: Wing-Fai Thi
Institution: Institute for Astronomy, Royal Observatory Edinbur

Technical Contact: Wing-Fai Thi, IfA/ROE

Co-Investigators:
Ewine van Dishoeck, Leiden Observatory
Emmanuel Dartois, Institut d'Astrophysique Spatiale
Christopher Wright, Australian Defense Academy

Science Category: young stellar objects
Observing Modes: IrsStare
Hours Approved: 2.0

Abstract:
We propose to perform a spectral survey with Spitzer-IRS at low- and high-spectral resolution of a sample of intermediate-mass young stellar objects ---the precursors of Herbig Ae/Be stars--- located in the Vela molecular cloud. Young stellar objects in the Vela molecular cloud provide an unique opportunity to study star-formation in the galactic plane in a luminosity range that has not been probed before. The main objectives of the program are: i) to establish an inventory of solids (silicates and ices); ii) to study their spatial variation throughout the envelopes; iii) to search for faint absorption features. The high quality spectra will allow a detailed study of the shape of the ice features (for example H2O ice at 6 micron, NH4+/CH3OH at 6.85 micron, CH4 at 7.6 micron, CO2 band at 15.2 micron and PAH emission. The shape of the CO2 ice bending mode is for instance a sensitive probe of the thermal history of the ices and is related to the formation of dioxide/methanol complexes. The study of the solid species will provide unprecedented constraints on chemical and radiative models of envelopes. Together with ground-based complementary spectra at lower wavelengths, the sample will constitute the first detailed spatial and spectral study of the solid content in envelopes around intermediate-mass young stellar objects, and provide crucial data for follow-up studies with Herschel.

Spitzer Space Telescope - General Observer Proposal #40600

Evolution of photoevaporating disks around massive Young Stellar Objects

Principal Investigator: Rens Waters
Institution: University of Amsterdam

Technical Contact: Arjan Bik, European Southern Observatory

Co-Investigators:
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Wing-Fai Thi, Institute for Astronomy, The University of Edinbur
Lex Kaper, University of Amsterdam, The Netherlands
Leticia Martin Hernandez, Instituto de Astrofisica de Canarias, Spain
Christoffel Waelkens, Katholieke Universiteit Leuven, Belgium
Thomas Henning, Max Planck Institut fuer Astronomie, Germany
Stan Kurz, Instituto de Astronomia-Morelia, Mexico
Els Peeters, University of Western Ontario, Canada
Carlos Alvarez Iglesias, Centro Comun de Astrofisica de La Palma, Spain

Science Category: young stellar objects
Observing Modes: IrsMap
Hours Approved: 23.0

Abstract:
Our unbiased near-IR survey of UCHII regions uncovered a group of massive Young Stellar Objects (YSOs) with dense, warm circumstellar material. These objects are ubiquitous. They show a bewildering range in properties of their circumstellar material: some display almost featureless and very red continua while others exhibit strong emission lines from both ionized and molecular material. The near-IR spectra of some of these objects show strong evidence for the presence of a remnant accretion disk. A striking result of the survey is that these massive YSOs belong to clusters where also "naked" O-type stars and near-IR counterparts to UCHIIs exist. We suspect that the differences in the observed circumstellar characteristics are related to the evolutionary status of the young massive star as well as the cluster environment. The proposed Spitzer spectroscopy in combination with a ongoing large observing programme at ESO's VLT (near-infrared Integral Field Spectrscopy), which provides us with a full sensus of the surrounding star-forming region, will allow us to disentangle the influence of the cluster environment on the circumstellar material from the differences in evolutionary status. With SPITZER/IRS we can test this hypothesis by studying the physical nature and composition of the circumstellar material of massive YSOs. The key question is: how do these new-born massive stars clear their environment as it is expected that the physical and chemical processes involved are fundamentally different from those acting in young low-mass stars? We propose to conduct IRS observations of 14 of the most isolated YSOs in our sample and request a total amount of time of 23.0 hours with SPITZER.

Spitzer Space Telescope - General Observer Proposal #40778

Spitzer-IRS observations of water-line emission in protostars

Principal Investigator: Dan Watson
Institution: University of Rochester

Technical Contact: Dan Watson, University of Rochester

Co-Investigators:
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Forrest Bill, U. Rochester
Elise Furlan, UCLA
Hartmann Lee, U. Michigan
Nuria Calvet, U.Michigan
Joan Najita, NOAO
Ted Bergin, U. Michigan
Sebastian Maret, U. Michigan
Gary Melnick, CfA
Paule Sonnentrucker, Johns Hopkins U.
Volker Tolls, CfA
Tom Megeath, U. Toledo

Science Category: young stellar objects
Observing Modes: IrsMap IrsStare
Hours Approved: 18.9

Abstract:
Recently, with Spitzer-IRS, we detected a rich mid-infrared emission-line spectrum from water in the Class 0 protostar NGC 1333-IRAS4B, that we showed to originate in a very dense, warm, solar-system-size region deeply embedded in the protostar?s envelope. We have interpreted the emission to arise in a disk accretion shock, and thus to reveal for the first time a long-sought view of the process of assembly of protoplanetary disks. Here we propose to follow up this discovery with more detailed observations of IRAS4B and its companion protostar IRAS4A, to search for more examples of this phenomenon among a sample of protostars selected for face-on view, and to apply more sophisticated models to determine the details of the structure, chemistry and evolution of the youngest protoplanetary disks.

Spitzer Space Telescope - General Observer Proposal #50560

Evolution of infall and envelope-disk accretion in protostars

Principal Investigator: Dan Watson
Institution: University of Rochester

Technical Contact: Dan Watson, University of Rochester

Co-Investigators:
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Tom Megeath, U. Toledo
Lori Allen, CfA
Ted Bergin, U. Michigan
Nuria Calvet, U.Michigan
Bill Forrest, U. Rochester
Elise Furlan, UCLA/NAI
Lee Hartmann, U. Michigan
Jim Houck, Cornell U.
Sebastian Maret, U. Michigan
Gary Melnick, CfA
Joan Najita, NOAO
Manoj Puravankara, U. Rochester
Paule Sonnentrucker, Johns Hopkins U.
Volker Tolls, CfA

Science Category: young stellar objects
Observing Modes: IrsStare
Hours Approved: 46.0

Abstract:
The discovery of water and OH line emission from the cores of Class 0 protostars is one of the most spectacular recent results from Spitzer, and opens one of the longest-sought regimes of star formation to detailed study: protostellar envelope infall, arrival of water (and other molecules) in the planet-forming regions of protoplanetary systems, and the process by which protoplanetary accretion disks are formed. With Spitzer-IRS we can detect such emission in substantial samples of protostars. We propose here to conduct such a survey, on a fiducial sample of 123 face-on Class 0 and Class I protostars in star-forming clouds lying 140-420 pc from the Solar system, with a 5-sigma disk-accretion-rate sensitivity of 2 - 8 E-6 solar masses per year. Detection of water and OH emission from this statistically-complete sample will enable a physical study of the evolution of infall, envelope-disk accretion, and the physical state of protoplanetary disks, through the era of protostellar-envelope settling and dissipation, that would be of fundamental importance in the study of star formation. In a complementary GTO proposal we will cover a much smaller sample of the highest accretion-rate protostars - seven of the eight objects in Orion A in which we have already detected water emission at low spectral resolution - in an exploration of the faintest features of OH, water, and its rare isotopologues.

Spitzer Space Telescope - Theoretical Research Proposal #30467

A Tool to Analyze Spitzer Data on Stellar and Young Stellar Objects

Principal Investigator: Barbara Whitney
Institution: Space Science Institute

Technical Contact: Barbara Whitney, Space Science Institute

Co-Investigators:
Thomas Robitaille, St. Andrews University
Kenneth Wood, St. Andrews University

Science Category: young stellar objects
Dollars Approved: 45913.0

Abstract:
We have produced a large grid of 2-D radiation transfer models for Young Stellar Objects (YSOs). We developed a tool that fits observed spectral energy distributions (SEDs) using models from the grid. Our grid includes stellar atmosphere models and a small set of evolved star spectra. The fitter automatically shows the uniqueness (or lack thereof) of a fit by presenting all good models within a specified chi-squared fit. A statistical algorithm estimates the best fit parameters from the set of good fits. The fitter is currently designed to work with data taken in broadband filters, such as the Spitzer IRAC and MIPS filters, and any others that a user provides. The fitter is optimized, and can fit large sets of data in a short amount of time. We request funds to expand the grid of models and to make the grid and fitter publicly available by web access. We will run a "second" generation grid of YSO models. These new models will include such improvements as 3-D clumpy models, PAH emission, and external radiation fields. We will also expand the stellar atmosphere and evolved star grid. This tool will be applicable for users analyzing large and small datasets on star formation regions as well as stellar populations and Galactic structure in the Galaxy and other nearby galaxies.

Spitzer Space Telescope - Theoretical Research Proposal #40794

An Improved Grid of YSO Radiative Transfer Models, and Further Analysis of SEDs and Images from Spitzer

Principal Investigator: Barbara Whitney
Institution: Space Science Institute

Technical Contact: Barbara Whitney, Space Science Institute

Co-Investigators:
Thomas Robitaille, St. Andrews University
Remy Indebetouw, University of Virginia
Matthew Povich, University of Wisconsin
Michael Wolff, Space Science Institute

Science Category: young stellar objects
Dollars Approved: 70247.0

Abstract:
Thanks to support from a previously funded Spitzer Theory proposal, we have made our grid of 200,000 Young Stellar Object Spectral Energy Distributions (YSO SEDs) and its companion data fitter publicly available. As part of that proposal, we promised to run a second generation grid of models that will be completed by Fall 2007. We have since identified additional models to run, as well as additional code development that will produce a significant advance over what was originally planned. In particular, the new radiation transfer code modifications will allow us to produce high signal-to-noise (S/N) images in addition to the SEDs at each of ten viewing angles in the 2-D models (and 200 in the 3-D models), as well as polarization maps and spectra. The SEDs will have much higher S/N, important for modeling IRS spectra, very embedded sources at IRAC wavelengths, and all sources at long wavelengths. The SEDs will be more accurate for edge-on disks, since they will not be averaged over a range of angles. As new models are computed, they will replace the ones in the 2007 grid, and the new grid will be designed to support expansion beyond the 2007 grid. The models run with the new code will take ~8 times longer. In addition, we plan to expand the number of models in the grid by at least a factor of two, based on requests from the community and our own work. We therefore request funds for a small but dedicated computer cluster to run models continuously over a period of a few years. We will use these tools to analyze star formation regions in the Galaxy and the LMC. We will also investigate the effects of source confusion on properties derived from the SED fitter.

Spitzer Space Telescope - Directors Discretionary Time Proposal #259

Testing Repeatable High-Precision Time Series Photometry with Spitzer: Observations of the Eclipsing Binary GU Bootes

Principal Investigator: Gerard van Belle
Institution: Caltech

Technical Contact: Stefanie Wachter, California Institute of Technology

Co-Investigators:
David Ciardi, Michelson Science Center
Don Hoard, SSC
Stefanie Wachter, SSC

Science Category: young stellar objects
Observing Modes: MipsPhot
Hours Approved: 8.9

Abstract:
We propose herein a carefully controlled set of Spitzer MIPS time series observations of the newly discovered low mass eclipsing binary star GU Bootes. These observations will serve to characterize the MIPS-24 observing techniques of the spacecraft, precisely establishing the photometric repeatability of this instrument at the sub-percent level. A rapid execution of this proposal will serve to substantiate the previously announced GO-1 and upcoming GO-2 observations of extrasolar planet transits at similar levels of precision. The ancillary science return will be the first-ever long wavelength characterization of such an object's light curve, allowing for improved characterization of the primary and secondary component linear radii, in addition to other aspects of their surface morphology.

Spitzer Space Telescope - General Observer Proposal #20707

Investigation of the Vega phenomenon among F-type stars of known infrared excess

Principal Investigator: Peter Abraham
Institution: Konkoly Observatory

Technical Contact: Peter Abraham, Konkoly Observatory

Co-Investigators:
Attila Moor, Konkoly Observatory
Daniel Apai, University of Arizona
Carol Grady, Eureka Scientific, NASA GSFC
Thomas Henning, Max-Planck-Institut fur Astronomie
Csaba Kiss, Konkoly Observatory
Ilaria Pascucci, University of Arizona

Science Category: circumstellar/debris disks
Observing Modes: IrsStare MipsPhot
Hours Approved: 35.1

Abstract:
One of the main discoveries of the IRAS mission was that main-sequence stars can be accompanied by circumstellar dust disks (Vega phenomenon). In this proposal we investigate a sample of 62 Vega candidate stars, whose infrared excess above the photosphere - indication for the presence of a disk - was in most cases already measured by ISO or IRAS. All stars are in the spectral range of F0-F9, resulting in a rather homogeneous sample in terms of stellar mass and luminosity. On the basis of IRS and MIPS observations, we study (i) the temporal evolution of debris disks, focusing on the evolution of the geometrical structure of the disk and of grain processing of the disk material; (ii) individual systems with very high fractional luminosity; (iii) old stars with warm debris disks; and (iv) debris disks in young moving groups. Our results will be used to verify model predictions for F stars, and they can also be compared with the outcome of similar programs dedicated to A- and G-type stars.

Spitzer Space Telescope - General Observer Proposal #3401

Study of an ISO-based sample of Vega stars: towards a better understanding of the evolutionary sequence

Principal Investigator: Peter Abraham
Institution: Konkoly Observatory

Technical Contact: Peter Abraham, Konkoly Observatory

Co-Investigators:
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Carol Grady, Eureka Scientific, NASA GSFC
Csaba Kiss, Max-Planck-Institut fuer Astronomie
Thomas Henning, Max-Planck-Institut fuer Astronomie
Guy Stringfellow, Univ. Colorado, Boulder

Science Category: circumstellar/debris disks
Observing Modes: IrsStare MipsPhot MipsSed
Hours Approved: 12.2

Abstract:
One of the main discoveries of the IRAS mission was that main-sequence stars can be accompanied by circumstellar dust disks (Vega phenomenon). In this proposal we investigate a sample of 16 Vega candidate stars, whose far-infrared excess above the photosphere - indication for the presence of a disk - was already well measured (5-10 sigma) at 60 and 90 micrometer by ISO. All stars are in the spectral range of F0-F9, therefore, due to the narrow mass range, the stellar luminosities do not change much within the sample. The temporal evolution of the density and temperature structure of the disks, as derived from the proposed observations, can be compared with models which predict that 1) the debris dust production site propagates outwards with time; 2) the relative contributions from small and large grains (which can be deduced from the shape of the disks spectrum) is also evolving with time. There are a number of GTO programmes plus a Legacy programme which are devoted to the Vega phenomenon. However, these proposals focus either on intermediate mass A-type or late F-, G-, K- type stars. Our proposed sample of 16 F stars would fill the gap between these two major categories. Debris disks with fractional luminosity higher than 10^{-3} are in a very special and short state of disk evolution. The sample contains five stars belonging to this interesting category of stars with debris disks, providing an excellent opportunity to study in details these very important cases. We propose to observe 16 F-type main-sequence stars with Spitzer. We obtain MIPS photometry and IRS low resolution spectra for each target in order to measure Vega-type excess at MIPS wavelengths, and to measure the short wavelength cut-off of the excess as well as search for solid-state features at the mid-infrared wavelengths. MIPS SED is requested for five objects to determine detailed SEDs in the far-infrared for the most spectacular (high fractional luminosity) targets. The total programme takes 12.2 hours.

Spitzer Space Telescope - General Observer Proposal #40566

THE ORIGIN OF WARM DEBRIS DISKS AROUND SOLAR ANALOGUES

Principal Investigator: Peter Abraham
Institution: Konkoly Observatory

Technical Contact: Peter Abraham, Konkoly Observatory

Co-Investigators:
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Daniel Apai, Steward Observatory
Carol Grady, Eureka Scientific; NASA GSFC
Ilaria Pascucci, University of Arizona
Csaba Kiss, Konkoly Observatory
Thomas Henning, MPIA, Heidelberg

Science Category: circumstellar/debris disks
Observing Modes: IracMap IrsStare MipsPhot
Hours Approved: 21.2

Abstract:
The Origin of Warm Debris Disks Around Solar Analogues One of the major discoveries of the IRAS mission was that many main-sequence stars are accompanied by circumstellar dust disks. Since the lifetime of dust grains in such disks is rather short, one assumes a planetesimal belt around the star, where collisions replenish the dust. Most known extrasolar debris disks are cold (50-90 K), and can be considered as the extrasolar analogues of our Kuiper belt. Warmer disks of 200-300 K are, however, rare: surveys of solar analogue main-sequence F,G or K stars discovered only about a dozen stars (2% of the observed systems) which harbour such kind of debris disks. These disks may be the closest - though somewhat brighter - analogues of our inner solar system. Many open questions are related to these spectacular objects, but perhaps the most interesting is their origin: were they formed via steady state evolution, or they are the product of transient dust-producing events, like collision of large asteroids, or a Late Heavy Bombardment (LHB)-like period. The answers may help to better understand the formation of the inner solar system, too. We propose to carry out detailed IRAC, IRS and MIPS observations of a well-selected large sample of 35 warm-disk candidates around F-G-K stars. Each system will be characterized in terms of disk structure and grain properties, and its most likely formation scenario will be outlined. Performing such an analysis on our whole sample we will give the first hints on how common are LHB-type events among Solar-analogue stars?

Spitzer Space Telescope - General Observer Proposal #20308

Probing the disk mineralogy and geometry of Herbig Ae/Be stars

Principal Investigator: Bram Acke
Institution: Katholieke Universiteit Leuven

Technical Contact: Bram Acke, Katholieke Universiteit Leuven

Co-Investigators:
Mario van den Ancker, ESO
Roy van Boekel, MPIA
Jeroen Bouwman, MPIA
Hans Van Winckel, KU Leuven
Rens Waters, Anton Pannekoek, Amsterdam

Science Category: circumstellar/debris disks
Observing Modes: IrsStare MipsSed
Hours Approved: 13.0

Abstract:
We propose to obtain IRS spectra (SH and LH mode), and MIPS SED observations of a sample of carefully selected Herbig Ae/Be stars. The observed spectral energy distribution of Herbig stars can be split up in roughly two groups: group I contains the strong mid-IR (20-100 micron) emitters, while group II sources have much more moderate excesses at these wavelengths. State-of-the-art models of protoplanetary disks indicate that the observational difference between the groups reflects the disk's geometry: group I sources have flared and group II self-shadowed disks. Moreover, we have found evidence that there is a evolutionary connection between both groups suggesting that flared disks evolve into self-shadowed disks as grain growth makes the grains settle to the disk's midplane. Unfortunately, the observational record till now is strongly biased towards the, by definition brighter, group I sources. This hampers our understanding of the evolution of protoplanetary disks around these stars. We therefore propose both IRS and MIPS spectroscopic observations which cover the vital wavelength region which defines the group I/II membership. The MIPS and IRS spectra will provide a powerful tool, not only to study in detail the connection between disk geometry and mineralogy of individual sources, but also to study the disk evolution by confronting our findings with the evolutionary timescales of the central objects. Moreover, disks surrounding binary post-AGB stars show remarkable similarities with those around group II Herbig stars. This resemblance sets stringent restrictions on the chemical and geometrical timescales involved in disk evolution. The unbiased sample of Herbig Ae/Be group I and II sources and the comparison with post-AGB binary disks will provide an excellent laboratory to investigate the phenomena which govern the physical processes in circumstellar disks. The ultimate goal of this proposal is to gain insight in the evolution of the protoplanetarey disks surrounding Herbig Ae/Be stars.

Spitzer Space Telescope - General Observer Proposal #3469

Infrared observations of an eclipsing binary T Tauri star

Principal Investigator: Eric Agol
Institution: University of Washington

Technical Contact: Eric Agol, University of Washington

Co-Investigators:
Jacqueline Kessler-Silacci, University of Texas
Catrina Hamilton, Rice University

Science Category: circumstellar/debris disks
Observing Modes: IracMap
Hours Approved: 1.2

Abstract:
The eclipsing T Tauri star KH 15D has a period of 48 days with eclipses of 3.5 magnitudes lasting for 20 days. The properties of this star can be explained if it is an eccentric binary T Tauri star with semi-major axis 0.28 AU and eccentricity 0.7 surrounded by a precessing ring of dust at 2-3 AU which is gradually eclipsing both stars. We wish to make infrared observations of this system to (a) constrain the inclination and width of the ring; (b) constrain the size of the dust within the ring to confirm evidence for grain-growth; (c) look for the presence of PAH, silicates or other mid-infrared features which may constrain the presence of smaller dust grains within the system. We will use our observations to measure the surface density of the edge of the ring which may be shaped by a shepherding planet.

Spitzer Space Telescope - General Observer Proposal #30551

Quantitative Mineralogy of Brown Dwarf Disks: Measuring the Effect of Luminosity on Dust Evolution

Principal Investigator: Daniel Apai
Institution: Steward Observatory/NASA Astrobiology Institute

Technical Contact: Daniel Apai, Steward Obs/NASA AI

Co-Investigators:
Ilaria Pascucci, Steward Observatory, University of Arizona
Kevin Luhman, The Pennsylvania State University
Michael R. Meyer, Steward Observatory
Thomas Henning, Max Planck Institute for Astronomy, Heidelberg
Antonella Natta, Arcetri Observatory
Jeroen Bouwman, Max Planck Institute for Astronomy, Heidelberg

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 25.2

Abstract:
The first step toward planetesimal formation is the processing of dust grains via grain growth and crystallization accompanied by dust settling toward the disk mid-plane. Our Cycle-1 IRS survey answered four questions concerning potential planet formation in brown dwarf disks: 1. Most brown dwarf disks are flat or only moderately flared; 2. We identified very high crystalline mass fractions (40-50%) in all but one brown dwarf disk. 3. Substantial grain growth occurs in brown dwarf disks already at very young ages (1-3 Myr). 4. The dust processing and the disk geometries are consistent with the picture of larger dust grains settling toward the disk mid-plane. The two most surprising findings were the highly crystalline disks and a dust compositional difference between sources in two different star-forming regions. We propose here to utilize 25.2 hours of Spitzer/IRS time to obtain very high signal-to-noise spectra to conduct a quantitative dust composition study on 22 disks around brown dwarfs and very low-mass stars. We aim to: 1, determine whether crystalline mass fractions decrease with age or with increasing luminosity; 2, confirm the dust compositional difference. Both questions are fundamental to understanding the processing and evolution of dust in protoplanetary disks - the raw material of terrestrial planets. Our team consists of some of the leading experts in the field of astromineralogy, protoplanetary disks, brown dwarf disks, and brown dwarf characterization. We have a strong record of successful Spitzer/IRS disk studies and all the reduction and analysis tools required to reach all proposed goals.

Spitzer Space Telescope - General Observer Proposal #30758

Evaporating disks

Principal Investigator: Zoltan Balog
Institution: University of Arizona

Technical Contact: Zoltan Balog, University of Arizona

Co-Investigators:
James Muzerolle, University of Arizona
George Rieke, University of Arizona

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 14.3

Abstract:
Evaporation in the vicinity of an O star disrupts protoplanetary disks, as seen in the Orion proplyds. We have found a number of evaporating disks with Spitzer, which are in some ways more dramatic and better oriented for detailed study than the proplyds - they have cometary tails extending up to 0.1 pc from the evaporation working surface. We will use Spitzer/IRS and HST/NICMOS to investigate these systems in more detail. We want to explore the excitation condition in the gas, both in the head and in the tail where possible. We will measure the effects of evaporation on the characteristic emission features of the dust. We also will use NICMOS to image them in detail, including mapping complex structures resolved in their tails at 24 microns

Spitzer Space Telescope - Archive Research Proposal #50465

Precise Ages for Debris Disk Stars via Gyrochronology

Principal Investigator: Sydney Barnes
Institution: Lowell Observatory

Technical Contact: Sydney Barnes, Lowell Observatory

Co-Investigators:
Katherine Su, University of Arizona
John Stansberry, University of Arizona
Gregory Henry, Tennessee State University

Science Category: circumstellar/debris disks
Dollars Approved: 75000.0

Abstract:
The Spitzer Space Telescope plays a leading role in identifying and investigating debris disks around nearby stars. This work will constitute one of its great scientific legacies. These debris disks are important because they probe analogs of our planetary system, and they could help understand the history of our own solar system. A key problem in assembling a picture of the evolution of these debris disk systems is that their ages are poorly known because sensitivity issues force us to work with field stars. There are two kinds of ages that are used: isochrone, and chromospheric. Isochrone ages for field stars have large errors (~100%), and furthermore, are biased oldward. Chromospheric ages, although better when available, still have errors ~50% and are also biased in certain ways, especially for F stars. As a result, not only is it not possible to identify possible breaks in the f_d vs. t relationship or the presence of individual events, but the decay relationship itself is known very poorly. We propose to use the new technique of gryochronology to refine the ages of a sample of ~50 field debris-disk host stars of solar-type. Gyrochronology, using a star's rotation period and color, allows the determination of the age of a field star to ~15-20%, a remarkable improvement in precision over the isochrone and chromospheric ages. The required rotation periods for the debris disk stars will be derived using an Automatic Photometric Telescope to measure the rotational modulation caused by transits of starspots. With accurate ages, we will be able to resolve LHB-like events if present, measure the decay relationship well, or indeed show that such a relationship does not generally hold.

Spitzer Space Telescope - Directors Discretionary Time Proposal #229

Dust around the Planet-bearing M Star Gliese 436

Principal Investigator: Charles Beichman
Institution: JPL

Technical Contact: Charles Beichman, JPL

Co-Investigators:
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E. Holmes, JPL
T. Velusamy, JPL
M. Shao, JPL
K. Staplfeldt, JPL
J. Lunine, U. of Arizona
G. Rieke, U. of Arizona
G. Marcy, UC Berkeley
D. Fischer, UC Berkeley
J. Greaves, ROE
W. Holland, ROE
M. Wyatt, ROE
W. Dent, ROE

Science Category: circumstellar/debris disks
Observing Modes: IrsStare MipsPhot
Hours Approved: 1.3

Abstract:
As Spitzer investigators with a direct interest in the search for debris disks around stars with planets based on our approved GO-1 program on Comparative Planetology, we would like to request 1.3 hr of Director's Discretionary time to observe Gliese 436. This M2.5 star is located just 10 pc away, and, as was just announced (Marcey et al. 2004), has a Uranus/Neptune mass planet orbiting it with a 3 day period. GJ436 will quickly become a critical star for future planet searches. Because of its proximity and low stellar mass, an Earth-mass planet orbiting GJ436 at 1 AU would be detectable by SIM. Spitzer will detect or set strong limits on a dust cloud (Kuiper or asteroid belt) associated with this star/planet system. Since the similarly nearby M star AU Mic has recently been found to have a prominent disk using coronagraphy (and Spitzer observations are planned), it would be of great interest to determine whether GJ436, only the second M star known to have a planet, also has an associated debris disk. Spitzer GTO data show that between 10-25% of mature (>3Gyr) F5-K5 stars with planets have prominent excesses at 70um (Beichman et al, in prep 2004), so there is a reasonable prospect of success even if this star is old. GJ436 is not in any GO or GTO program that we can identify.

Spitzer Space Telescope - General Observer Proposal #2324

The SIM/TPF Sample: First Steps in the Comparative Planetology of Neighboring Solar Systems

Principal Investigator: Charles Beichman
Institution: JPL

Technical Contact: Charles Beichman, JPL

Co-Investigators:
Keith Grogan, JPL
Elizabeth Holmes, JPL
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Geoff Marcy, UCBerkeley
Debra Fischer, UC Berkeley
Jane Greaves, ROE
William Dent, ROE
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MArk Wyatt, ROE

Science Category: circumstellar/debris disks
Observing Modes: IracMap IrsStare MipsPhot MipsSed
Hours Approved: 42.0

Abstract:
In the coming decade, astronomers will characterize the constituents of neighboring solar systems, including gas-giant planets, dust and gas from Kuiper Belt objects, comets and asteroids, and ultimately terrestrial planets using the Space Interferometer Mission (SIM) and the Terrestrial Planet Finder (TPF). While the Spitzer telescope has neither the sensitivity nor the angular resolution to detect individual planets, Spitzer is uniquely positioned to characterize the evolution, amount, structure and composition of the dust associated with Kuiper and asteroid belts around stars with and without planets. We request 49.9 hours of Spitzer/MIPS time to observe 165 stars to complete a de facto survey of nearby stars looking for debris disks that has been initiated by a variety of GTO and Legacy programs. The goals of the survey include: 1. Completing a large census to enable statistical investigations of the debris disk phenomenon in terms of the age, metallicity, and spectral type of parent stars. 2. Correlating the amount of debris disk emission with planets that have been or will be discovered through a variety of techniques (radial velocity searches, SIM and TPF) to deepen our understanding of the relationship of the presence of planets to the properties of debris disks. 3. Understanding the potential influence of zodiacal emission on the eventual detectability of planets. 4. Finding the stars with excesses suitable for follow-up by telescopes at other wavelengths. We will conduct an efficient survey at 24 and 70 micron to identify stars with excesses and will carry out a modest second-look program to characterize more fully the disks we detect. Our team includes experts in determining the physical properties of nearby stars, in developing SED and dynamic models of disks, and in analyzing MIPS observations.

Spitzer Space Telescope - General Observer Proposal #40109

Planet-Disk Interactions and the Origin of the HD69830 Debris Disk

Principal Investigator: Charles Beichman
Institution: Jet Propulsion Laboratory

Technical Contact: Charles Beichman, Jet Propulsion Laboratory

Co-Investigators:
Geoff Bryden, JPL
Carey Lisse, JHU
mark Wyatt, Cambridge

Science Category: circumstellar/debris disks
Observing Modes: IracMap IrsStare MipsPhot
Hours Approved: 24.9

Abstract:
One of the most dramatic Spitzer discoveries to date has been the extreme level of zodiacal emission around the nearby (12.6 pc) K0V star HD 69830. The dust cloud around HD69830 has more than 1,400 times the emission of our own zodiacal cloud and shows a plethora of solid state features attributable to small, hot, crystalline silicate grains located within 0.5 AU of the parent star. Interest in this cloud and its link to the evolution of planetary systems was greatly heightened by the discovery of three Neptune-mass planets orbiting within 0.5 AU of the star. The HD 69830 system promises to be the premier laboratory for the study of the interaction been a debris disk and a planetary system. Closer examination of the spectrum reveals silicates and a smattering of sulfides and carbonates, and some water ice. The dust appears to be consistent with ejecta from the destruction of a 30 km asteroid of the S-(or possibly P/D-) type. We request 24.9 hours of Spitzer time to make high signal- to-noise, low- and high-spectral resolution observations of the dust disk and to improve constraints on the amount of cold Kuiper Belt emission at 70 um. This definitive dataset would allow us to improve substantially our modeling of the composition and spatial distribution of the emitting dust which will in turn help to distinguish between an asteroidal and cometary origin of the material. This request includes three repeats of the spectral observations designed to search for small variations that might be expected from a dust cloud evolving with a dynamical time of less than 1 year. Our team has extensive experience with Spitzer data analysis for both IRS and MIPS, detailed compositional modeling, and dynamical modeling of complex planet-disk interactions. Only Spitzer can provide a complete spectrum of the debris disk excess region and hold out the unique prospect of finding evolution in the disk structure and/or composition on the dynamical timescale of the system.

Spitzer Space Telescope - Directors Discretionary Time Proposal #528

Monitoring the Variability of the HD69830 Zodiacal Cloud

Principal Investigator: Charles Beichman
Institution: JPL

Technical Contact: Charles Beichman, JPL

Co-Investigators:
Geoff Bryden, JPL
Casey Lisse, JHU
Mary Wyatt, Cambridge U.

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 1.5

Abstract:
Examination of our Spitzer/IRS data from 3 epochs (two in 2007 and the discovery observations in 2004) show significant changes in the small grain content of the debris disk surrounding the star HD69830. The dynamical time scale for this disk is of order of 1 yr and the existence of 3 planets within 1 AU, where the debris cloud is located, makes the continuous disruption of large solid bodies likely. HD69830 is the premier laboratory for disk-planet interactions. We request 1.5 hours of IRS/LoRes time to extend the time baseline to allow us to monitor this variability.

Spitzer Space Telescope - General Observer Proposal #50793

IR Excesses of Central Stars of Planetary Nebulae

Principal Investigator: Jana Bilikova
Institution: University of Illinois, Urbana-Champaign

Technical Contact: Robert Gruendl, UIUC

Co-Investigators:
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Robert Gruendl, University of Illinois, Urbana-Champaign
Kate Su, University of Arizona
Thomas Rauch, Universitat Tubingen
Kevin Volk, Gemini Observatory
Orsola De Marco, American Museum of Natural History

Science Category: circumstellar/debris disks
Observing Modes: IrsMap IrsStare MipsPhot
Hours Approved: 2.8

Abstract:
Dust disks have been detected around binary post-AGB stars, central stars of planetary nebulae (CSPNs), and white dwarfs (WDs). It is not clear whether some of the dust disks have a common origin and persist through the stellar evolution. To search for connections among these dust disks, we have used archival Spitzer observations to survey 40 resolved planetary nebulae and their central stars. IR excesses indicating the existence of dust disks are found in four CSPNs - in NGC 2346, NGC 2438, NGC 6804, and NGC 7139. To accurately measure the continuum fluxes and to search for spectral features of dust grains, we request IRS and MIPS 24 um observations of these nebulae, while avoiding duplication of the archival data. The IRS observations will allow us to unambiguously separate line and continuum emission components and to search for mineralogical features of dust grains, and the MIPS 24 um observations allow us to extend the SEDs to longer wavelengths for better constraint of the dust temperature and distance from the central star. The results will be used to assess the nature of the IR excess and the origin of the dust, and possible link these dust disks to those around post-AGB stars and WDs.

Spitzer Space Telescope - General Observer Proposal #20691

The evolution of circumstellar disks as traced by coeval stellar clusters: from protoplanetary towards debris disks.

Principal Investigator: Jeroen Bouwman
Institution: Max Planck Institute for Astronomy

Technical Contact: Jeroen Bouwman, Max Planck Institute for Astronomy

Co-Investigators:
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Christine Chen, NOAO
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Ilaria Pascucci, Steward Observatory
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Science Category: circumstellar/debris disks
Observing Modes: IrsMap IrsStare MipsPhot
Hours Approved: 20.2

Abstract:
Observations have revealed that dust undergoes a profound processing in protoplanetary disks around young stars on a time scale of ~1 to 20 Myr. Dust grains condense, are chemically altered, and/or crystalize, and grow through coagulation. Eventually, these processes may culminate in the formation of a planetary system. At the same time, the disk evolves on a global scale. The disk geometry may change from flaring to a more flattened structure. The disk may also develop gaps and eventually will dissipate.These processes will be heavily influenced by the characteristics of the star (or stars) and its interaction with the disk. The importance of these different factors is presently not well known. We propose an infra-red spectroscopy and photometry study of a complete and unbiased sample of all young stellar objects in 4 associations, with the aim of characterizing the dust in the circumstellar disks.The observations will directly provide us with the composition, size and amount of dust present as well as the geometry (eg., flaring), mass, and gaps in the global structure of the disk. Because each association is coeval, the effects of time on the dust and the disks can be separated from those due to the variation in stellar parameters. Intercomparison of the properties of the dust and the disks derived for the different associations provides then a handle on the temporal aspects of the dust and disk evolution around young stellar objects. This proposal is very complementary to the legacy and GTO observations which focus on the brightest young stellar objects.

Spitzer Space Telescope - General Observer Proposal #30726

Nature vs. Nurture: The influence of OB star environments on proto-planetary disk evolution.

Principal Investigator: Jeroen Bouwman
Institution: Max Planck Institute for Astronomy

Technical Contact: Jeroen Bouwman, Max Planck Institute for Astronomy

Co-Investigators:
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Aurora Sicilia Aguilar, Max-Planck Institute for Astronomy
Leisa Townsley, Penn State University
Junfeng Wang, Penn State University

Science Category: circumstellar/debris disks
Observing Modes: IracMap IrsStare
Hours Approved: 28.0

Abstract:
A natural approach for understanding the origin and diversity of planetary systems is to study the birth sites of planetary systems under varying environmental conditions. Dust grains in protoplanetary disks, the building blocks of planets, are structurally and chemically altered, and grow through coagulation into planetesimals. The disk geometry may change from a flaring to a more flattened structure, gaps may develop under the gravitational influence of protoplanets, and eventually the disk will dissipate, terminating the planet formation process. While the infrared properties of disks in quiet cloud environments have been extensively studied, investigations under the conditions of strong UV radiation and stellar winds in the proximity of OB stars have been limited. We propose a combined IRAC/IRS study of a large, well-defined and unbiased X-ray selected sample of pre-main-sequence stars in three OB associations: Pismis 24 in NGC 6357, NGC 2244 in the Rosette Nebula, and IC 1795 in the W3 complex. The samples are based on recent Chandra X-ray Observatory studies which reliably identify hundreds of cluster members and were carefully chosen to avoid high infrared nebular background. A new Chandra exposure of IC 1795 is requested, and an optical followup to characterise the host stars is planned. Modelling the Spitzer findings will provide the composition and size of dust present as well as the geometry, mass, and gaps in the global structure of the disk. As hundreds of cluster members will be covered with IRAC and dozens with IRS, good statistics on the disk evolution and dispersal as a function of location with respect to OB stars will be obtained. Comparison of disk properties within our sample and with existing Spitzer studies of quiescent star-forming regions should significantly advance the aim of characterising the influence of the environment on the evolution of protoplanetary disks. This effort relies on a powerful synergy between the Chandra and Spitzer Great Observatories.

Spitzer Space Telescope - General Observer Proposal #3470

The mineralogy of proto-planetary disks surrounding Herbig Ae/Be stars

Principal Investigator: Jeroen Bouwman
Institution: Max Planck Institute for Astronomy

Technical Contact: Jeroen Bouwman, Max Planck Institute for Astronomy

Co-Investigators:
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A Tielens, Kapteyn Institure, University of Groningen
L.B.F.M. Waters, Astronomical Institute University of Amsterdam
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M. Min, Astronomical Institute, University of Amsterdam
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M. van den Ancker, ESO, Garching
Chr Leinert, MPIA, Heidelberg
B. Vandenbussche, Astronomical Institute, University of Leuven
Wing-Fai Thi, Astronomical Institute, University of Amsterdam

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 14.4

Abstract:
We propose to use the IRS on board of the Spitzer Space Telescope to study the mineralogy of dust in the planet-forming disks that surround intermediate-mass pre-main-sequence stars. The mid-infrared spectral region has an amazing richness of solid state resonances of abundant materials, that are sensitive to grain growth and grain processing. Most importantly, such observations will probe the presence of minerals that are also found to be common in the solar system. Therefore, the proposed observations will provide a unique opportunity to compare on-going planet formation with the historic records of the formation of the solar system as found in meteorites, interplanetary dust particles and comets. Existing data sets show a tremendous variation in spectral shape and dust composition, but sample size and quality of the data preclude establishing clear trends. A large sample of stars is required to study the way interstellar dust grains are processed to form new planetary systems. The proposed observations, in combination with the existing GTO and Legacy programs will form a complete census of known nearby, isolated Herbig~Ae stars, allowing for a systematic study into the evolution of planet-forming disks.

Spitzer Space Telescope - General Observer Proposal #50360

A deep look at the evolution of 4-10 Myr old disks in Orion OB1

Principal Investigator: Cesar Briceno
Institution: Centro de Investigaciones de Astronomia (CIDA)

Technical Contact: Cesar Briceno, CIDA

Co-Investigators:
Nuria Calvet, University of Michigan
Jesus Hernandez, University of Michigan/CIDA
James Muzerolle, Steward Observatory, University of Arizona
Catherine Espaillat, University of Michigan
Lee Hartmann, University of Michigan

Science Category: circumstellar/debris disks
Observing Modes: IracMap MipsScan
Hours Approved: 29.6

Abstract:
We propose to obtain deep IRAC/MIPS observations of recently discovered populations of stars with ages 4-10 Myr in the Orion OB1 association. Many of the young members in these regions are concentrated in distinct stellar aggregates, with differing ages, but presumably sharing a common origin. Among them is the 25 Ori group, by far the most populous 10 Myr old sample yet known within 500 pc. Our ongoing large-scale survey of the Orion OB1 star-forming region has allowed us to find these elusive populations and secure the photometric and spectroscopic data needed to fully determine the stellar and accretion properties of these objects, from ~3 solar masses down to the lowest mass stars at the substellar boundary. The proposed Spitzer IRAC/MIPS observations, combined with existing ground-based optical and near-infrared data, will yield spectral energy distributions for characterizing protoplanetary disks, as a function of stellar mass and environment. This will enable us to discern the overall trends in circumstellar disk evolution during the important age range 4-10 Myr, when planet formation and disk dissipation are expected to occur, thus providing the best constraints yet for theoretical models in this pivotal stage.

Spitzer Space Telescope - General Observer Proposal #30070

Testing the first direct measurement of cataclysmic variable evolution: the search for a circumbinary disk or a low-mass companion around NN Serpentis

Principal Investigator: Carolyn Brinkworth
Institution: Caltech/JPL

Technical Contact: Carolyn Brinkworth, Caltech/JPL

Co-Investigators:
Donald Hoard, Spitzer Science Center
Tom Marsh, University of Warwick, UK
Stefanie Wachter, Spitzer Science Center

Science Category: circumstellar/debris disks
Observing Modes: IracMap
Hours Approved: 1.6

Abstract:
We obtained high time-resolution photometry using the high speed CCD camera ULTRACAM between 2002 and 2004, which revealed a gradual reduction in the orbital period of the pre-cataclysmic variable NN Serpentis. There are three possible explanations for this period change: firstly, we may have been successful in obtaining the first and only direct measurement of the braking rate of a close binary system, in which case our measured values are approximately 2 orders of magnitude greater than predicted, and pose serious problems for the theory of close binary evolution. Secondly, the unusually high braking rate may be caused by the presence of a circumbinary disk, which would help to answer two of the outstanding problems with current CV theory - namely the high mass-transfer rates seen in some CVs, and the fact that the minimum observed value in the CV period distribution is approximately 15% longer than expected. Finally, our observations could be explained by a light travel-time effect caused by a third body in orbit around the binary, which would raise major questions about the evolutionary history of the system, in particular how a third body has managed to remain in a stable orbit throughout periods of intense mass-loss in the central binary. We intend to use IRAC observations to search for a mid-infrared excess in the spectral energy distribution of NN Ser, which would confirm the presence of either a disk or a third body. We then propose to use HST imaging to attempt to resolve a third body, allowing us to discriminate between the two possibilities. If both methods fail to reveal any extra system components, we will have ruled out our only remaining alternatives to a genuinely high angular momentum loss rate in this system, with profound implications for CV evolution.

Spitzer Space Telescope - General Observer Proposal #40048

An intensive study of the planetary debris disks around the single white dwarfs SDSS1228+1040 and SDSS1043+0855

Principal Investigator: Carolyn Brinkworth
Institution: Spitzer Science Center

Technical Contact: Carolyn Brinkworth, Spitzer Science Center

Co-Investigators:
Tom Marsh, University of Warwick
Boris Gaensicke, University of Warwick

Science Category: circumstellar/debris disks
Observing Modes: IracMap IrsPeakupImage
Hours Approved: 4.3

Abstract:
While > 200 extrasolar planets orbiting main sequence stars have been discovered, the destiny of planetary systems through the late stages of evolution of their host stars is very uncertain, and no planet has been found around a white dwarf. We have identified metal-rich gas disks around two relatively young white dwarfs, SDSS 1228+1040 and SDSS 1043+0855. A dynamical model of the double-peaked emission lines constrains the outer disk radius in SDSS 1228+1040 to just 1.2 solar radii. The likely origin of such a disk is a tidally distrupted asteroid, which has been destabilised from its initial orbit of more than 1000 solar radii by the interaction with a relatively massive planetessimal object or a planet. Here we propose a Spitzer study to test for a cooler, dusty extension to the gaseous disks around both white dwarfs. In particular we will model the mass of material in the disks, thereby placing tighter constraints on their origin and evolution. In the unlikely event that we fail to detect a cooler extension to the gaseous disks, we will have an even more exciting problem on our hands, with the possibility that the disks are either extraordinarily young and are still in the process of spreading, or they are somehow prevented from spreading by as-yet undetected, extremely low-mass companions to the white dwarfs.

Spitzer Space Telescope - General Observer Proposal #50058

Circumbinary dust disks - reconciling the theory of close binary evolution with observation

Principal Investigator: Carolyn Brinkworth
Institution: Caltech/JPL

Technical Contact: Carolyn Brinkworth, Caltech/JPL

Co-Investigators:
Donald Hoard, Spitzer Science Center
Tom Marsh, Univ. of Warwick, UK

Science Category: circumstellar/debris disks
Observing Modes: IracMap IrsPeakupImage
Hours Approved: 2.8

Abstract:
The evolution of all close binary systems is driven by the loss of angular momentum from the system. Standard theory invokes two mechanisms for this loss - gravitational radiation and magnetic braking - and forms the backbone of virtually all studies based on binary evolution rates. Recent studies, however, have shown that the extrapolations in which the standard theory is based are wrong, suggesting that the true evolutionary rate of binary systems should be 10 - 10000 slower than previously predicted. To confuse the matter further, observational studies show that binary systems are actually evolving around 1000 times faster than this revised theory suggests, leading to the speculation that there is another angular momentum loss mechanism at work. One of the more likely candidates is the presence of a cool, dusty disk around the binary, which drains angular momentum from the system via tidal coupling. We propose to combine a Spitzer search for circumbinary dust disks with results from an ongoing project to directly measure the evolutionary rates of a number of detached binary systems. By modelling these disks, we will be able to test for any correlation between disk mass and evolutionary rate, and test whether the presence of these dusty disks could finally bring the theory of close binary evolution into line with observation.

Spitzer Space Telescope - General Observer Proposal #50118

Planetary debris disks around hot white dwarfs - dusty extensions to hot gaseous disks

Principal Investigator: Carolyn Brinkworth
Institution: Caltech/JPL

Technical Contact: Carolyn Brinkworth, Caltech/JPL

Co-Investigators:
Boris Gaensicke, University of Warwick
Tom Marsh, University of Warwick, UK
Donald Hoard, Spitzer Science Center

Science Category: circumstellar/debris disks
Observing Modes: IracMap MipsPhot IrsPeakupImage
Hours Approved: 5.0

Abstract:
While >250 extrasolar planets orbiting main sequence stars have been discovered, the destiny of planetary systems through the late stages of evolution of their host stars is very uncertain, and no planet has ever been found around a white dwarf. We identified metal-rich gas disks around two relatively young white dwarfs, SDSS 1228+1040 and SDSS 1043+0855. The likely origin of such a disk is a tidally disrupted asteroid, which has been destabilised from its initial orbit of more than 1000 solar radii by interaction with a relatively massive planetessimal or planet. Our Spitzer Cycle 4 photometry of SDSS 1228+1040 detected a cool, dusty extension to the warm gaseous disk. Preliminary modelling of the infrared excess suggests that it cannot be modelled with a single optically-thick or -thin dusty debris disk, but instead requires a two-stage disk, with an optically thick inner disk, and an optically thin cooler outer disk. Intriguingly, the SED increased faster towards 16 microns than we expected, and our modelling suggests that the disk cannot be continuous, but must have a gap of about 100 Earth-radii between the optically thick and optically thin disks. The most likely mechanism for clearing a gap in a dust disk is the presence of a planetessimal still intact around the star. Here we propose to observe this disk at longer wavelengths to further constrain our model and confirm the presence of this gap in the disk, and to carry out a similar study on a third, almost identical hot, single WD recently identified in the Sloan Digital Sky Survey.

Spitzer Space Telescope - General Observer Proposal #50340

Searching for ancient planetary systems - a Spitzer survey for planetary debris disks around metal-rich white dwarfs

Principal Investigator: Carolyn Brinkworth
Institution: Caltech/JPL

Technical Contact: Carolyn Brinkworth, Caltech/JPL

Co-Investigators:
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Donald Hoard, Spitzer Science Center
Tom Marsh, University of Warwick, UK

Science Category: circumstellar/debris disks
Observing Modes: IracMap IrsPeakupImage
Hours Approved: 24.0

Abstract:
Over the past decade there has been an explosion in the number of planets found around other stars, and yet, despite this, we have very little idea of the final fate of these planetary systems as their host stars evolve off the main sequence and become white dwarfs. While no planet has ever been found around a white dwarf, we have begun to piece together the puzzle of their fate with the discovery of debris disks around a number of isolated, metal-rich white dwarfs. White dwarfs are generally extremely metal-poor, since their high surface gravity causes heavy elements to settle out of their atmospheres in a matter of a few tens of years. Those that have metals in their atmospheres must therefore be accreting them from some external source. Recent research has shown that the metal abundances in these systems are too high for the system to be accreting from the ISM, and a more likely explanation is that most or all of them are accreting from some kind of circumstellar disk. Searches for debris disks around these metal-rich white dwarfs have been extremely successful, with estimates that up to 15-20% of them may have a dusty circumstellar disk. Despite this success rate, a large number of the bright, metal-rich white dwarfs in the McCook and Sion catalogue remain unobserved with Spitzer. We propose to observe all of the remaining bright metal-rich white dwarfs with IRAC and, where possible, IRS Peak-up imaging to search for debris disks in these systems. Modelling of these disks will answer a wide range of questions about the evolution and composition of both the disks and their planetary system progenitors.

Spitzer Space Telescope - General Observer Proposal #20065

Debris Disks around COROT Target Stars

Principal Investigator: Geoffrey Bryden
Institution: JPL

Technical Contact: Geoffrey Bryden, JPL

Co-Investigators:
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George Rieke, Univ. of Arizona

Science Category: circumstellar/debris disks
Observing Modes: IrsStare MipsPhot
Hours Approved: 5.8

Abstract:
Within CoRoT's limited field of view we will search around the brightest stars for excess IR emission. Debris disks are potentially important for both science goals of the CoRoT mission, asteroseismology and exoplanet detection. For exoplanets, we have found that debris disks are correlated with the presence of giant planets; this correlation may well extend down to the telluric planets which CoRoT is hoping to locate. In has also been calculated that cometary tails may be detectable should they cross the face of their parent star. The influence of asteroidal and cometary debris on stellar structure via surface accretion is unclear, and can be addressed with CoRoT's seismological probing of the stellar interior. Overall, the detection of circumstellar material around these stars, in addition to furthering our knowledge of debris disks and their link to planetary systems, has great value in planning CoRoT observations and in interpreting its results. Our targets include 12 of the 14 candidate primary stars plus 1 additional star under consideration as a secondary CoRoT target. One primary star was excluded based on its estimated cirrus background. Another, the G0 star HD52265, we have already observed with Spitzer, resulting in the detection of circumstellar dust orbiting at tens of AU and clearly demonstrating the ability of MIPS to accurately measure IR excess within our sample of stars.

Spitzer Space Telescope - General Observer Proposal #30157

Fine-Scale Imaging of Newly Resolved Debris Disks around Solar-Type Stars

Principal Investigator: Geoffrey Bryden
Institution: JPL

Technical Contact: Geoffrey Bryden, JPL

Co-Investigators:
Charles Beichman, MSC/JPL
Karl Stapelfeldt, JPL
George Rieke, Univ. of Arizona
Angelle Tanner, MSC/JPL

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 17.2

Abstract:
We have surveyed ~200 nearby solar-type stars for IR excess, with a detection rate of ~15%. Of the stars identified as having circumstellar emission, ~10 are marginally resolved in their MIPS 70 μm images. Beyond the "Fabulous Four", these are the only debris disks that have been spatially resolved by Spitzer. Several have independent evidence for disk extension, most notably HD 139664, for which an edge-on disk has been recently imaged with HST. Our MIPS image of this disk matches HST's in both size and position angle. We propose to obtain 70 μm fine scale images for 7 debris disk systems to further resolve the disks and to improve our understanding of their properties. We also request 160 μm data for 4 of the systems. 160um images will further constrain the distribution of dust temperatures within the disks and, if the disks continue out to large radii, can resolve the cold emission from the outer disk. In the absence of spatial information, flux measurements can only determine a representative dust temperature, not its location. By combining SED-derived dust temperatures with direct measurements of the dust extent, we can 1) remove the ambiguity in determining the orbital location of the dust emission, 2) determine the location of the colliding planetesimal belts that create the dust, 3) measure the average dust emissivity and infer a typical grain size, 4) relate debris disk sizes to those of protostellar disks to help understand where planetesimals form, 5) for stars with known planets, correlate the dust location with planetary orbits, and 6) relate the dust distribution to theoretical models of disk sculpting by planets, particularly for cases where the observed disk structure is asymmetric. Overall, these results will help us to understand the evolution of both the individual systems studied and, by extension, the greater sample of unresolved solar-type debris disks.

Spitzer Space Telescope - General Observer Proposal #30434

The brown dwarf that was swallowed by a red giant and survived

Principal Investigator: Matt Burleigh
Institution: University of Leicester

Technical Contact: Matt Burleigh, University of Leicester

Co-Investigators:
Paul Dobbie, University of Leicester (UK)
Ralf Napiwotzki, University of Hertfordshire (UK)
Pierre Maxted, University of Keele (UK)
Carolyn Brinkworth, Spitzer Science Center / JPL
Donald Hoard, Spitzer Science Center
Stefanie Wachter, Spitzer Science Center

Science Category: circumstellar/debris disks
Observing Modes: IracMap
Hours Approved: 0.7

Abstract:
We have discovered, through optical radial velocity measurements, the first confirmed close white dwarf + brown dwarf binary. Since the system is double-lined, we are able to determine the companion's mass as 0.055+/-0.005Msun, placing it firmly in the substellar regime. The orbital period is 115 minutes, and no mass transfer is taking place. Therefore, the brown dwarf must have survived a previous common envelope phase of evolution, during which it was engulfed by the red giant precursor's envelope. The discovery of this system raises the possibility that lower mass substellar objects, including giant planets, may also survive the red giant phase to become close companions to white dwarfs. Indeed, they may accrete a significant amount of mass during this phase. A small excess K band flux above that expected from the white dwarf is found in 2MASS photometry, enabling us to place a tentative upper limit on the brown dwarf's spectral type as mid-L. We request Spitzer IRAC photometry of the binary to more accurately determine the brown dwarf's spectral type (to one subclass), and to measure precise fluxes and an effective temperature. These data will be used to understand how this unique binary has been created: has the brown dwarf accreted a significant amount of matter during the common envelope phase? Was it originally a lower mass brown dwarf or even a giant planet? If yes, this has implications for the fate of all planets and brown dwarfs in the post main-sequence phase of evolution.

Spitzer Space Telescope - General Observer Proposal #50530

Confirming a second Helix-like cool debris disk

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Paul Steele, University of Leicester
Ralf Napiwotzki, University of Hertfordshire, UK
Hans Zinnecker, Astrophysikalisches Institut Potsdam, Germany
Paul Dobbie, Anglo-Australian Observatory

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 0.4

Abstract:
An IRAC observation of the central star of the old planetary nebula DeHt5 (WD2218+706) reveals excess emission at 8 microns, above that expected from the white dwarf alone. We can match this emission with a 100K blackbody, and it bares striking similarity to the so-far unique 100K excess emission observed for the central star of the Helix nebula (Su et al. 2007). MIPS photometry of the Helix has revealed the presence of a large, cool debris disk between 30-150AU from the central star, which may be the result of collisions in a Kuiper-belt during post-main sequence evolution. We will obtain MIPS photometry of WD2218+706 to confirm the excess emission, better constrain its temperature, mass and geometry, and compare it to the Helix. The confirmation of a second Helix-like disk around this older white dwarf would also enable us to begin investigation of the evolution of these debris disks with time.

Spitzer Space Telescope - General Observer Proposal #20408

Dust processing in the protoplanetary disks of the Orion OB1 Association

Principal Investigator: Nuria Calvet
Institution: University of Michigan

Technical Contact: Nuria Calvet, University of Michigan

Co-Investigators:
Cesar Briceno, Centro de Investigaciones de Astronomia (CIDA)
James Muzerolle, Steward Observatory
Lee Hartmann, Smithsonian Astrophysical Observatory
Paola D'Alessio, Instituto de Astronomia UNAM - Morelia
Edwin Bergin, Department of Astronomy, University of Michigan

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 2.1

Abstract:
We propose to obtain mid-IR spectra using IRS on board Spitzer of four ~5 Myr old stars in the Orion OB1b association, which show indications of an advanced degree of dust evolution in their disks, and for which the ground-based observations suggest they are in the critical phase just prior to the opening of gaps in their disks. Our ongoing large-scale survey of the Orion OB1 star-forming region has allowed us to secure the ground-based photometric and spectroscopic data needed to fully characterize the stellar and accretion properties of these objects, including the mass accretion rates in their inner disks. Combined with the Spitzer IRS data and our theoretical analysis, we will be able to shed light on the state of solids in disks in which protoplanets may already be forming and starting to open gaps. Our analysis will include assesing the distribution of dust and its mineralogy. We have also requested time with HST to obtain far-UV spectra of these objects. These spectra, if the time is granted, will provide crucial information on the gas in the inner disk, which together with the Spitzer mid-IR data will allow us to build a comprehensive view, and gain unprecedented insight into the physical processes characterizing the evolution of gas and dust in inner circumstellar disks.

Spitzer Space Telescope - General Observer Proposal #3437

Disk Evolution in the Orion OB1 Association

Principal Investigator: Nuria Calvet
Institution: University of Michigan

Technical Contact: Nuria Calvet, University of Michigan

Co-Investigators:
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Cesar Briceno, CIDA
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Paola D'Alessio, Instituto de Astronomia UNAM

Science Category: circumstellar/debris disks
Observing Modes: IracMap MipsScan
Hours Approved: 11.0

Abstract:
We propose to conduct a comprehensive study of circumstellar disk emission in the Orion OB1 association using all the instruments on the Spitzer Space Telescope. The Orion OB1 association offers a unique laboratory for understanding disk structure and evolution in a distributed population of low mass young stars over an age range of 1-10 Myr. The pre-main sequence population spread out over 100 square degrees in this region has been well-characterized by our group via an extensive ground-based optical survey. IRAC and MIPS maps of two representative regions with different ages will allow us to study complete spectral energy distributions out to 24 microns, diagnosing the structure of circumstellar disks from the strength and shape of the excess infrared continuum emission. Additional IRS spectra of a small sample of objects with existing ground-based mid-IR detections will provide more detailed information about the dust content of the disks. In combination with detailed modeling, the data will provide key insights into the processes affecting disk evolution in a non-clustered environment with nearby massive stars, including effects such as dust settling and inside-out clearing which are critical influences on planet formation.

Spitzer Space Telescope - General Observer Proposal #40247

Probing the Gas in the Planet Forming Regions of Protoplanetary Disks

Principal Investigator: Nuria Calvet
Institution: University of Michigan

Technical Contact: Catherine Espaillat, University of Michigan

Co-Investigators:
Catherine Espaillat, University of Michigan
James Muzzerolle, University of Arizona
Elise Furlan, UCLA
Lee Hartmann, University of Michigan
Edwin Bergin, University of Michigan
Jon Miller, University of Michigan

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 46.8

Abstract:
By studying the inner, planet-forming regions of circumstellar disks around low-mass pre-main sequence stars we can refine theories of giant planet formation and develop timescales for the evolution of disks and their planets. Spitzer low-resolution IRS observations of T Tauri stars (TTS) in the Chamaeleon, IC 348, and NGC 2068/2071 star-forming regions have given us an unprecedented look at dust evolution in young objects spanning 1-3 Myr. However, despite this ground breaking progress in studying the dust in young disks, the gas properties of the inner disk remain essentially unknown. With high resolution IRS, we propose to search for 12.81 micron Neon fine structure emission originating in the innermost disk regions of classical TTS in different stages of evolution with the objective of revealing the timescales of gas dissipation and its relationship to dust evolution. These observations will complement ground-based gas studies with Magellan/MIKE and Gemini/Phoenix. With the combined results of Spitzer, Gemini, and Magellan, our theoretical analysis will unveil the state of the dust and gas in disks in which planets may already be forming and starting to open gaps.

Spitzer Space Telescope - General Observer Proposal #50403

Mind the Gap: Timing Planet Formation by Looking in the Holes and Gaps of Dusty Disks

Principal Investigator: Nuria Calvet
Institution: University of Michigan

Technical Contact: Catherine Espaillat, University of Michigan

Co-Investigators:
Catherine Espaillat, University of Michigan
James Muzerolle, University of Arizona
Dan Watson, University of Rochester
Lee Hartmann, University of Michigan
Elise Furlan, UCLA/NAI

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 5.0

Abstract:
Uncovering the details of disk dissipation is critical to understanding the formation of planetary systems. In the past few years Spitzer has greatly aided in this task by giving us an unprecedented view of dust clearing in the inner regions of protoplanetary disks, most notably through observations of stars with inner disks that are mostly devoid of small dust i.e. the "transitional disks." Recently, Spitzer has identified a new class of "pre-transitional disks" with significant near-infrared excesses which indicate the presence of an optically thick inner disk separated from an optically thick outer disk, suggesting the incipient development of disk gaps as opposed to the inner holes seen in transitional disks. Here we propose for five hours of IRS time to study variability in 18 transitional and pre-transitional disks in Taurus and Chamaeleon in order to refine planet formation theories. The prospect of detecting variability in these objects is favorable based on IRS data taken in the past few weeks showing that transitional disks exhibit extreme variability due to the behavior of optically thin dust within the inner disk hole. Variability in transitional and pre-transitional disks can be linked with planets interacting with dust in the holes and gaps of these disks and therefore this study will help provide estimates of spatial inhomogeneities and characteristic timescales of changes for planet formation models.

Spitzer Space Telescope - Archive Research Proposal #50406

A closer look at protoplanetary disk structure

Principal Investigator: Nuria Calvet
Institution: University of Michigan

Technical Contact: Catherine Espaillat, University of Michigan

Co-Investigators:
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Dan Watson, University of Michigan
Lee Hartmann, University of Michigan
Nathan Crockett, University of Michigan

Science Category: circumstellar/debris disks
Dollars Approved: 125000.0

Abstract:
We propose to model and interpret the SEDs of disks in Taurus and Chamaeleon, including the IRS spectra and IRAC and MIPS photometry. These samples include full disks, transitional disks, and pre-transitional disks, that is, disks in different stages of evolution of their solid content. They include disks around stars covering a range of stellar parameters, with masses from ~2.5 M_sun down to the substellar limit, and mass accretion rates from a few 10^-7 M_sun/yr down to a few 10^-10 M_sun/yr. We will use our irradiated accretion disk models including dust settling, which successfully reproduce the range of emission characteristics of young disks. Our self-consistent approach to model these disks will give us the ability to compare derived dust properties among different stellar and accretion parameters. This effort will provide considerable insight into the mechanisms determining the disk structure and evolution.

Spitzer Space Telescope - General Observer Proposal #20069

Circumstellar Disk Evolution Across the Stellar Mass Spectrum in the Upper Scorpius OB Association

Principal Investigator: John Carpenter
Institution: California Institute of Technology

Technical Contact: John Carpenter, California Institute of Technology

Co-Investigators:
Eric Mamajek, Harvard-Smithsonian Center for Astrophysics
Lynne Hillenbrand, California Institute of Tecnology
Michael Meyer, University of Arizona

Science Category: circumstellar/debris disks
Observing Modes: IracMap IrsPeakupImage MipsPhot
Hours Approved: 121.8

Abstract:
Most 1 Myr old solar-type stars are surrounded by optically thick circumstellar accretion disks that undoubtedly represent the formation sites of planetary systems. Based on Spitzer and ground-based surveys from near-infrared to submillimeter wavelengths, it is becoming increasingly clear that by an age of 10 Myr, the reservoir of primordial small dust grains in disks has been drastically depleted over all orbital radii. If planet formation is a common outcome of the star formation process, evidently the time period between 1 and 10 Myr represents the critical evolutionary stage where the raw disk material is converted into larger bodies. We therefore propose a comprehensive, joint Spitzer-NOAO photometric survey spanning 0.4 to 70 microns of 208 members of the 3-5 Myr old Upper Scorpius OB association. Upper Sco contains the largest identified sample of stars in this age range, and at a distance of 145 pc, is a factor of three closer than the next populous OB association of comparable age. By surveying a large sample of stars over the full range of stellar masses (0.1 to 15 solar masses), our proposed survey will: i) measure the frequency of disks as a function of stellar mass soon after stars have emerged from the parental molecular cloud; ii) determine the diversity of disk architectures based on the shape of the spectral energy distribution; and iii) establish the evolutionary pathways of circumstellar disks by comparing the Upper Sco results with existing Spitzer surveys of young (1 Myr) stars in molecular clouds. No other Spitzer survey probes the full range of stellar masses in this critical age range of disk evolution at the proposed sensitivity.

Spitzer Space Telescope - General Observer Proposal #30091

Circumstellar Disks in the Upper Scorpius OB Association

Principal Investigator: John Carpenter
Institution: California Institute of Technology

Technical Contact: John Carpenter, California Institute of Technology

Co-Investigators:
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Eric Mamajek, Smithsonian Astrophysical Observatory
Michael Meyer, University of Arizona
Lynne Hillenbrand, California Institute of Technology

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 42.1

Abstract:
Most 1 Myr old stars are surrounded by circumstellar accretion disks that undoubtedly represent the formation sites of planetary systems. Based on Spitzer and ground-based surveys from near-infrared to submillimeter wavelengths, it is becoming increasingly clear that by an age of 10 Myr, the reservoir of primordial dust grains in disks has been drastically depleted over all orbital radii. If planet formation is a common outcome of the star formation process, evidently the time period between 1 and 10 Myr is a critical evolutionary stage when the raw disk material is converted into larger bodies. We are currently conducting a photometric survey of the 5 Myr old Upper Scorpius OB association using IRAC, MIPS, and the IRS 16um peak-up array that will probe the frequency of disks in this period of disk evolution. From the initial results of our survey we have identified 30 sources with masses ranging from brown dwarfs to late B-type stars that are surrounded by circumstellar disks. The proposed observations will enable us to 1) determine the diversity of disk architectures at a fixed age based on variations in the spectral energy distribution within our sample; 2) constrain the grain composition and the occurrence of grain growth from the shape of spectral features at 10um and 18um; and 3) establish the temporal evolution of disks as a function of mass by comparing our results with younger star-forming regions being studied by other Spitzer programs.

Spitzer Space Telescope - General Observer Proposal #40096

Debris Dust around Extrasolar Planetary Systems

Principal Investigator: John Carpenter
Institution: California Institute of Technology

Technical Contact: John Carpenter, California Institute of Technology

Science Category: circumstellar/debris disks
Observing Modes: IrsStare MipsPhot
Hours Approved: 96.6

Abstract:
Spitzer is extending the IRAS legacy by surveying the prevalence of debris disks over all stellar masses, ages, and environments. Hundreds of debris systems have now been detected, and raises the exciting possibility that planet formation is a common outcome of the star formation process. While the statistics of debris disks are becoming well established, the properties of the planetary systems that ignite the collisional cascade to produce the debris dust remain in question. To advance our understanding of the debris disks discovered with Spitzer, we propose to obtain a comprehensive census of debris dust around extrasolar planetary systems. Given that the planetary masses and orbits are known from radial velocity measurements, the proposed observations will establish any empirical relationships between the frequency, temperature, and luminosity of debris disks with planetary mass and orbits. These data will also test basic principles of debris disk models by determining i) if the warm inner disk is truncated by gravitational interactions with planets, ii) whether the expected migration of hot Jupiters disrupts the planetesimal belt, and iii) if massive planets accelerate collisional processing of the planetesimal belt. Any correlations between debris properties and planetary architectures identified from this survey will serve as a template to interpret the larger ensemble of debris systems discovered with Spitzer.

Spitzer Space Telescope - General Observer Proposal #40104

Timescale for Gas-giant Planet Formation in A- and B-stars

Principal Investigator: John Carpenter
Institution: California Institute of Technology

Technical Contact: John Carpenter, California Institute of Technology

Co-Investigators:
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Uma Gorti, NASA-Ames
Scott Dahm, California Institute of Technology
Jenny Patience, University of Exeter

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 27.5

Abstract:
Most 1 Myr old stars are surrounded by circumstellar accretion disks that undoubtedly represent the formation sites of planetary systems. Based on Spitzer and ground-based surveys from near-infrared to submillimeter wavelengths, it is becoming increasingly clear that by an age of 10 Myr, the reservoir of primordial dust grains in disks has been drastically depleted over all orbital radii for more than 90% of solar type stars. However, these observations do not constrain the lifetime of the gas, whose evolution may be decoupled from the dust. The lifetime of gas in primordial circumstellar disks has fundamental consequences for the formation of Jovian planets, dynamical evolution of terrestrial planets, and migration of planetesimals and dust grains. In a recent Spitzer photometric survey of the 5 Myr Upper Sco OB association, we identified a population of 10 A- and B- type stars surrounded by circumstellar disks with large (> 10 AU) inner holes inferred from the dust component. These disks are at an advanced evolutionary stage relative to the optically-thick, gas-rich primordial disks found around Herbig Ae/Be stars, and may represent the latter stages in the dissipation of primordial disks or the formative stages of debris systems. Given the relative youth of Upper Sco, this sample represents an important population to establish the gas dissipation time scales around A- and B- stars. We propose to obtain IRS high resolution spectra of these 10 stars to search for gas emission lines from Ne II, Ne III, S, Fe II, and molecular hydrogen. By combining these observations with our complementary ground-based survey, we can search for gas over the entire disk and determine if these disks retain sufficient mass of gas to form Jovian planets, or whether we are observing an end-stage in primordial disk evolution that establishes an upper limit on the timescale to form gas-giant planets in A- and B-type stars.

Spitzer Space Telescope - General Observer Proposal #20363

Grain Settling and Growth in the Planet Formation Region of Disks

Principal Investigator: John Carr
Institution: Naval Research Laboratory

Technical Contact: John Carr, Naval Research Laboratory

Co-Investigators:
Joan Najita, National Optical Astronomy Observatory

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 12.0

Abstract:
We propose to measure the gas-to-dust ratio in a sample of protoplanetary disk atmospheres in order to determine the amount of grain settling and growth at planet formation distances. These processes are a basic and important step in the planet formation process, but direct evidence for them is lacking for the inner disk (< 10 AU). High-resolution IRS spectra of classical T Tauri stars will be obtained to measure the gas content using molecular and atomic diagnostics in the MIR. By modeling the gaseous emission spectra along with IRS low-resolution spectra of dust emission features and continuum, we will be able to determine the gas and dust columns and grain sizes, and constrain the amount of both grain settling and growth in disk atmospheres.

Spitzer Space Telescope - General Observer Proposal #2300

Evolution of Gaseous Disks and the Formation of Giant and Terrestrial Planets

Principal Investigator: John Carr
Institution: Naval Research Laboratory

Technical Contact: John Carr, Naval Research Laboratory

Co-Investigators:
Joan Najita, National Optical Astronomy Observatory
David Hollenbach, NASA Ames Research Center
Uma Gorti, NASA Ames Research Center

Science Category: circumstellar/debris disks
Observing Modes: IrsMap
Hours Approved: 30.0

Abstract:
The remarkable diversity in the properties of the extrasolar planets shows that planet formation can lead to a wide variety of outcomes, including planetary systems very different from our own. This diversity raises a fundamental question: What is the likelihood of forming solar systems like ours? One way to address this issue is by studying the planet formation process as it occurs around nearby young stars. We propose to explore the gaseous component of planet-forming disks from the onset of giant planet formation through the epoch of the assembly of terrestrial planets (ages 1--10 Myr). Our observations, which will probe the gas content of disks over the range of radii relevant to planet formation (< 10 AU), will address issues that bear on the possibility of forming solar systems like our own. The proposed observations will [1] determine the timescale available to form giant planets and therefore identify dominant pathways for giant planet formation; [2] identify systems in which giant planets may be forming through core accretion; [3] measure the gas mass and dissipation timescale in the terrestrial planet region of the disk, an important factor in determining the likelihood of forming Earth-like planets.

Spitzer Space Telescope - General Observer Proposal #50641

Water and Organic Molecules in the Planet Formation Region of Disks

Principal Investigator: John Carr
Institution: Naval Research Laboratory

Technical Contact: John Carr, Naval Research Laboratory

Co-Investigators:
Geoffrey Blake, CalTech
Klaus Pontoppidan, CalTech
Colette Salyk, CalTech
Joan Najita, NOAO
Fred Lahuis, SRON Groningen
Ewine van Dishoeck, University of Leiden

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 59.6

Abstract:
Recent results from Spitzer demonstrate dramatic advances in our ability to probe the gaseous component of disks. When observed at high signal-to-noise (S/N), circumstellar disks are found to show a rich spectrum of atomic and molecular (water, OH, organics) lines that originates in the planet formation region of the disk (radius<10 AU). Water vapor is found to be abundant and substantial molecular abundance variations are observed in the handful of disks studied at high S/N. These results demonstrate the feasibility of using the spectroscopy of gaseous disks to probe the physical and chemical processes that drive planet formation and disk evolution. We therefore propose high S/N Spitzer IRS SH+LH spectroscopy of a sample of objectss spanning a range of evolutionary ages, stellar luminosities, and dust disk geometries. The proposed observations will (i) explore the extent to which we can detect the formation of planetesimals or icy planets by the chemical signature that they are expected to impose on the gaseous inner disk; (ii) search for chemical evidence of the disk turbulence that is predicted by theories of disk accretion; and (iii) provide an independent probe of the extent of grain settling in disks, an important first step in planet formation. These path-finding observations will lay the foundation for studies of gaseous disks at planet formation distances.

Spitzer Space Telescope - Archive Research Proposal #20204

Are Dust Disks and Circumstellar Gas Around Young A Stars Unrelated Phenomena?

Principal Investigator: Kwang-Ping (Patricia) Cheng
Institution: California State University, Fullerton

Technical Contact: Kwang-Ping Cheng, CSU-Fullerton

Co-Investigators:
James Neff, College of Charleston

Science Category: circumstellar/debris disks
Dollars Approved: 51829.0

Abstract:
The first three IRAS discovered protoplanetary/planetary candidates (Vega, Beta Pictoris, and Alpha PsA) are all main-sequence A stars. Subsequent studies strongly suggest that Beta Pictoris could be an early solar system. If the high-density, high-velocity circumstellar (CS) gas falling toward Beta Pic were fueled by grazing comets or ongoing erosion of debris located close to the star, we would expect to find evidence for warm dust in all Beta Pic-like systems. We have carried out detailed studies of the CS environments of all nearby A stars. We have studied not only their CS dust but also the characteristics of their CS gas, using visual and UV spectroscopy. Based on our ground-based, IUE, HST, and FUSE observations, we have identified about a dozen main-sequence A stars with CS gas. Among them, several have dynamic CS gas (infall and outflow similar to that observed around Beta Pic) but no IRAS detectable infrared excess. Since Spitzer can probe these systems at least ten times more sensitively than IRAS, we propose to analyze the available archival Spitzer data of nearby A stars with detectable CS gas. Our goals are (1) to probe the link between the dust and gas of A stars' circumstellar disks, which can provide important constraints on models of disk evolution and planet formation, and (2) to better understand main-sequence A stars in general based on our combined observations in IR, visual, UV, and far-UV.

Spitzer Space Telescope - Directors Discretionary Time Proposal #241

Dust to Dust: A Study of Second-Generation Debris in Scorpius-Centaurus

Principal Investigator: Christine Chen
Institution: NOAO

Technical Contact: Christine Chen, NOAO

Science Category: circumstellar/debris disks
Observing Modes: IrsStare MipsSed
Hours Approved: 10.0

Abstract:
Planets, asteroids, and comets are believed to form in circumstellar disks of gas and dust with ages <100 Myr. Although these objects are not detected directly in disks, their presence can be inferred from observations of spatial structure (e.g. gaps, central clearings, and warps) and transient gas phase molecules and atoms. I plan to carry out a multi-wavelength study of 5 - 20 Myr old F-, G-, and K-type stars in the nearest OB Association, Scorpius-Centaurus, to search for these signposts of Solar System body formation and to study the evolution of solids from instellar dust grains to parent bodies. I am leading an effort by Spitzer GTO Mike Jura to search for dusty disks around ~120 solar-like stars in Sco-Cen using MIPS at 24 micron and 70 micron. Our first observations from this program have discoved more than a dozen objects with fractional infrared luminosities as high as 1.0e-3 (Chen et al. 2005). Follow-up Spitzer IRS data, obtained in collaboration with the IRS Disks team, will be combined with Spitzer MIPS SED mode observations to determine the composition of dust grains in these systems. High resolution ground-based, mid-infrared imaging in N- and Q-band will directly constrain the location of warm dust grains and, when compared with high resolution scattered light imaging, may help determine the grain albedo and whether snow lines exist in these systems. High resolution visual spectroscopy will allow us to search for circumstellar gas, which may either be remnant gas, left over from the formation of the system, or secondary-gas, generated by the sublimation of infalling cometesimals.

Spitzer Space Telescope - General Observer Proposal #40235

Evolution and Dust Dynamics in ScoCen Circumstellar Disks

Principal Investigator: Christine Chen
Institution: National Optical Astronomy Observatory (NOAO)

Technical Contact: Christine Chen, NOAO

Co-Investigators:
Michael Jura, UCLA
Dan Watson, University of Rochester
Alycia Weinberger, Carnegie Institution of Washington

Science Category: circumstellar/debris disks
Observing Modes: IrsStare MipsPhot
Hours Approved: 86.2

Abstract:
The Scorpius-Centaurus OB association (ScoCen), with typical stellar distances of 115 - 145 pc, is the closest OB association to the Sun and contains three subgroups: Upper Scorpius (US), Upper Centaurus Lupus (UCL), and Lower Centaurus Crux (LCC), with estimated ages of ~5 Myr (Preibisch et al. 2002), 17 Myr, and 16 Myr (Mamajek et al. 2002), respectively. The close proximity of ScoCen and the youth of its constituent stars make this association an excellent laboratory for studying the formation and evolution of planetary systems. We propose to obtain MIPS 24 micron and 70 micron photometry of ~280 stars in UCL and LCC to complete our comprehensive survey of disks in this region and study disk evolution as a function of stellar properties. Our previous study discovered ~40 sources with 24 micron excess in a survey of 115 solar-like stars; some of which possess solid state emission features. We propose to obtain second-look IRS spectroscopy for ~35 disk systems to determine the spatial distribution of dust and search for emission features that may reveal grain composition. In addition, we request Chandra ACIS-S observations of 10 solar-like stars to resolve source confusion in the ROSAT catalog and to search for an anti-correlation between x-ray activity and infrared excess; such an anti-correlation could demonstrate that corpuscular stellar wind drag is an important grain removal mechanism around 20 Myr old solar-like stars.

Spitzer Space Telescope - General Observer Proposal #40953

MIPS Survey of Dust Disks around Hot White Dwarfs

Principal Investigator: You-Hua Chu
Institution: University of Illinois, Urbana-Champaign

Technical Contact: Robert Gruendl, UI, Urbana-Champaign

Co-Investigators:
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Robert Gruendl, Universtiy of Illinois, Urbana-Champaign
Thomas Rauch, Universitat Tubingen
Kevin Volk, Gemini Observatory

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 15.1

Abstract:
Spitzer observations of the Helix Nebula have revealed a bright 24 and 70 um source at the central star, a white dwarf (WD) with an effective temperature of 110,000 K. A Spitzer IRS spectrum of this source confirms that the emission is dust continuum. The analysis of Spitzer observations lead to the conclusion that the hot WD is surrounded by a dust disk at a distance of 40-100 AU, and that the dust is freshly produced by collisions of dynamically perturbed Kuiper-Belt-like Objects (KBOs) or comets. The collisions of these KBOs/comets with the central WD or the accretion of the dust may generate the mysterious 1 keV X-ray emission observed from the WD. We propose a MIPS 24 um survey of a sample of hot (>100,000 K) WDs that either are in old planetary nebulae or belong to a variety of spectral classes to search for dust disks up to a distance of 100 AU from the star, with a sensitivity of 34 uJy. Hot WDs provide an opportunity for the last glimpse at the outer planetary systems of stars before they cool and fade into oblivion. The results will be used to study the evolution of planetary systems throughout the stellar lifetime. The proposed survey can test the hypothesis that 1 keV X-rays can be generated by accreting comets or dust, and thus finally solve the mystery of hard X-ray emission from single WDs.

Spitzer Space Telescope - General Observer Proposal #50629

The Nature of the 24 Micron Excess Emission from Hot White Dwarfs

Principal Investigator: You-Hua Chu
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Technical Contact: Robert Gruendl, UIUC

Co-Investigators:
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Robert Gruendl, University of Illinois, Urbana-Champaign
Jana Bilikova, University of Illinois, Urbana-Champaign
Thomas Rauch, Universitat Tubingen
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Orsola De Marco, American Museum of Natural History

Science Category: circumstellar/debris disks
Observing Modes: IracMap IrsMap IrsStare MipsPhot
Hours Approved: 15.5

Abstract:
Spitzer observations of the Helix Nebula have revealed a bright 24 and 70 um source at the central star, a white dwarf (WD) with an effective temperature of 110,000 K. A Spitzer IRS spectrum of this source confirms that the emission is dust continuum. The analysis of Spitzer observations leads to the conclusion that this hot WD is surrounded by a dust disk at a distance of 40-100 AU, and that the dust may be freshly produced by collisions of dynamically perturbed Kuiper-Belt-like Objects or comets. To determine whether the dust disk around the Helix central WD is a common phenomenon, we have conducted a MIPS 24 um survey for a sample of 72 hot (>100,000 K) WDs that either are in old planetary nebulae or belong to a variety of spectral classes. Among the 51 objects that have been observed, four hot WDs are detected at 24 um and show fluxes more than 100 times higher than their expected photospheric emission. To determine the nature and origin of the excess 24 um emission we request (1) low-resolution IRS observations to unambiguously separate line and continuum emission components and to search for mineralogical features of dust grains; (2) IRAC observations at 3.6-8.0 um; and (3) MIPS 70 um observations of these hot WDs. These observations will allow us to measure the dust continuum emission, derive its temperature and distance from the central star, and assess the origin of the dust.

Spitzer Space Telescope - General Observer Proposal #20463

A Search for Warm Dust in the Habitable Zones Around Solar-Type Stars

Principal Investigator: David Ciardi
Institution: Michelson Science Center

Technical Contact: David Ciardi, Michelson Science Center

Co-Investigators:
Charles Beichman, MSC/Caltech
Angelle Tanner, JPL
Geoff Bryden, JPL
Karl Stapelfeldt, JPL
David Harker, UCSD
Rachel Akeson, MSC/Caltech

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 68.0

Abstract:
Spitzer is uniquely positioned to characterize the evolution, amount, structure and composition of the warm dust located within the habitable zones around many types of stars. We propose to observe 152 FGKM stars within 25 pc of the Sun to address the frequency, amount, and properties of warm dust located within the habitable zones around solar-like stars. IRS 7 - 35 um observations will be used to detect the presence of warm dust beyond the detection capabilities of MIPS at 24 um,and provide detailed information about the mass, size, distribution, and mineralogy of the warm dust located within a few AU of the stars. The proposed survey is complementary to the other current and proposed Spitzer surveys. In addition, the proposed observations lay the foundations for future studies with the Keck Interferometer and for understanding the influence of the exozodiacal emission in potential TPF targets.

Spitzer Space Telescope - General Observer Proposal #50773

Testing the Disk Regulation Paradigm with Spitzer: low mass stars

Principal Investigator: Lucas Cieza
Institution: Institute for Astronomy, University of Hawaii

Technical Contact: Lucas Cieza, IfA, University of Hawaii

Co-Investigators:
Nairn Baliber, University of California, Santa Barbara
Lars Bildsten, University of California, Santa Barbara

Science Category: circumstellar/debris disks
Observing Modes: IracMap
Hours Approved: 11.2

Abstract:
Using Spitzer data, we have recently shown an unambiguous correlation between pre-main sequence (PMS) star rotation periods and the presence of a circumstellar disk for stars with spectral type M2 and earlier in the young Orion Nebula Cluster and NGC 2264, providing the first clear evidence that star-disk interaction regulates PMS star angular momentum as they evolve onto the main sequence. Because Spitzer data allows the populations of stars with and without disks to be separated accurately, a quantitative analysis of the angular momentum history of these clusters is now underway using Monte Carlo simulations. Parameters such as the disk release timescales, angular momentum transfer efficiency, and fractions of stars released by their disksas a function of time can be constrained. However, current IRAC data for these clusters is too shallow to study stars later than M2, a group which represents half the population of stars with known rotation periods and a fundamentally different regime from the higher-mass stars. There is a sharp break in the behavior of the rotation period distributions at spectral type ~M2.5, suggesting a significant change in the efficiency or nature of the disk regulation mechanism at this boundary. Only by studying an unbiased and statistically significant sample of stars with M3 and later spectral types will we be able to establish whether or not a disk regulation mechanism is operating on very low mass stars. Whatever the answer turns out to be, it will have very important implications for the fields of angular momentum evolution of PMS stars, disk evolution, and/or stellar structure. We propose deep IRAC photometry of one 7x7 IRAC field centered on the NGC 2264 cluster (600 sec/pixel) to recover disk information for all low-mass stars with known periods. NGC 2264 is the only suitable cluster for which these observations may be made, and Spitzer's IRAC is the only instrument with the necessary sensitivity beyond 5 microns to conduct them.

Spitzer Space Telescope - General Observer Proposal #20742

Spitzer imaging and photometry of two 1 Gyr old debris disks within 20 pc of the Sun

Principal Investigator: Mark Clampin
Institution: NASA GSFC

Technical Contact: Mark Clampin, NASA GSFC

Co-Investigators:
Paul Kalas, UC Berkeley
James Graham, UC Berkeley

Science Category: circumstellar/debris disks
Observing Modes: IracMap MipsPhot MipsSed
Hours Approved: 12.8

Abstract:
We report the first scattered light detections of two debris disk around an F star and a K star using optical coronagraphy and the Hubble Space Telescope. With ages ~1 Gyr, these are the oldest debris disks thus far seen in the optical. We have discovered ring-like structure and azimuthal asymmetry that can be linked to dynamical perturbations of yet-undetected planetary companions. We propose deep, multi-roll angle IRAC imaging with SST to search for substellar objects, to constrain the presence of a warm dust component in the disk, and to identify its spatial location within the disk's structure. MIPS photometry will be employed to anchor the spectral energy distribution of the disks at longer wavelengths. Since these debris disks are close to our Kuiper Belt in an evolutionary context, detailed understanding of their mass, structure and composition will provide a fresh perspective for inferring the history and properties of our own trans-Neptunian region.

Spitzer Space Telescope - Archive Research Proposal #20044

Archival Study of Hyades Debris Disks

Principal Investigator: William Cochran
Institution: University of Texas at Austin

Technical Contact: William Cochran, University of Texas at Austin

Co-Investigators:
Diane Paulson, NASA Goddard Space Flight Center
Michael Endl, University of Texas at Austin
Lucas Cieza, University of Texas at Austin

Science Category: circumstellar/debris disks
Dollars Approved: 57620.0

Abstract:
We propose to use the Spitzer Space Telescope archival IRS, IRAC and MIPS observations of 17 stars in the Hyades star cluster to augment the data that we are obtaining in our Cycle 1 GO program 3371, in order to search for remnant debris disks in a homogeneous sample of stars of 625My age. The dominant independent variable in the sample is the stellar mass. The age of the Hyades corresponds to the era of the late heavy bombardment in our solar system about 3.9Gy ago. Thus, it is reasonable to believe that these Hyades dwarfs might also have rapidly evolving debris disks at this age. Our combined sample stars range from F8V to M2V. We have measured the effective temperature, surface gravity, micro- and macro-turbulence, the abundance of Fe, Si, Ti, Na, Mg, Ca, and Zn, the projected rotational velocity (v sin i), as well as the stellar chromospheric activity index for most of the stars in the sample. Any remnant debris disks around these Hyades stars would have escaped detection by IRAS, and would have been near the sensitivity limit of ISO if they are similar in properties to a solar-type zodiacal disk.

Spitzer Space Telescope - General Observer Proposal #3371

Debris Disks Around Hyades Stars

Principal Investigator: William Cochran
Institution: University of Texas at Austin

Technical Contact: William Cochran, University of Texas at Austin

Co-Investigators:
Lucas Cieza, University of Texas at Austin
Diane Paulson, University of Michigan
Michael Endl, University of Texas at Austin

Science Category: circumstellar/debris disks
Observing Modes: IracMap MipsPhot
Hours Approved: 25.0

Abstract:
We propose to use the Spitzer Space Telescope to obtain IRAC and MIPS photometry of a sample of 94 stars in the Hyades star cluster, in order to search for remnant debris disks in a homogeneous sample of stars of 625My age. The dominant independent variable in the sample is the stellar mass. The age of the Hyades corresponds to the era of the late heavy bombardment in our solar system about 3.9Gy ago. Thus, it is reasonable to believe that these Hyades dwarfs might also have rapidly evolving debris disks at this age. The sample stars were selected from our ground-based high precision radial velocity survey of Hyades dwarfs to search for Jupiter-mass companions. They range from F8V to M2V. We have measured the effective temperature, surface gravity, micro- and macro-turbulence, the abundance of Fe, Si, Ti, Na, Mg, Ca, and Zn, the projected rotational velocity (V sin i), as well as the stellar chromospheric activity index for most of the stars in the sample. Any remnant debris disks around these Hyades stars would have escaped detection by IRAS, and would have been near the sensitivity limit of ISO if they are similar in properties to a solar-type zodiacal disk. We will model the IR excesses observed to determine dust distributions and dust grain properties. The models will consider the dust chemical composition, the dust grain size distribution, disk radiative transfer (scattering, absorption, and thermal reemission of stellar flux by dust grains) and the physical distribution of dust grains within the disk.

Spitzer Space Telescope - General Observer Proposal #3607

KH 15D: Infrared Emission from Gas and Dust, Near and Far

Principal Investigator: Drake Deming
Institution: NASA's Godddard Space Flight Center

Technical Contact: Drake Deming, NASA's Godddard Space Flight Center

Co-Investigators:
David Charbonneau, California Institute of Technology
Eugene Chiang, Univ. of California at Berkeley
Joseph Harrington, Cornell University

Science Category: circumstellar/debris disks
Observing Modes: IrsStare MipsPhot
Hours Approved: 2.1

Abstract:
The unusual eclipsing object KH 15D is a weak-lined T Tauri star showing deep periodic eclipses, which must be produced by circumstellar matter. Although weak-lined T Tauri stars are not usually undergoing significant accretion, KH 15D has other spectroscopic properties normally associated with actively accreting stars. For example, it exhibits a rich spectrum of shocked molecular hydrogen emission, rivaled only by T Tauri itself. Moreover, the nature of the KH 15D eclipses is varying with time. The system has recently been explained as a spectroscopic binary in which a nodally-precessing circumbinary ring is gradually blocking the binary star. This model immediately calls for mid-IR observations to detect the thermal emission of the circumbinary ring, and verify its existence. We propose low spectral resolution observations using IRS and MIPS to detect thermal emission from the dusty ring which lies in the inner environment of the system, and high resolution long-wavelength spectroscopy to search for forbidden atomic lines, and rotational lines of molecular hydrogen, formed in the outer environment of the system.

Spitzer Space Telescope - General Observer Proposal #30807

Cool Material Around Metal-Rich White Dwarfs

Principal Investigator: Jay Farihi
Institution: Gemini Operations North

Technical Contact: Jay Farihi, Gemini Operations North

Co-Investigators:
Ben Zuckerman, University of California, Los Angeles
Michael Jura, University of California, Los Angeles
Eric Becklin, University of California, Los Angeles

Science Category: Circumstellar/Debris Disks
Observing Modes: IracMap MipsPhot
Hours Approved: 18.3

Abstract:
We propose MIPS 24 micron imaging for a sample of nearby very metal-rich white dwarfs in order to detect excess emission due to relatively cool dust. The main science goal is to further explore the connection between debris disks orbiting white dwarfs with photospheric metals by probing their circumstellar environments, with unprecedented sensitivity, for cool dust. Our target sample includes both hydrogen-rich degenerates with metals (spectral type DAZ) as well as their helium-rich counterparts (spectral type DBZ or DZ). Recent surveys, including ongoing work by our team, have discovered a few white dwarfs with evidence for warm dust via excess emission in the 2-8 micron region and there are reasons why we might expect that cooler dust awaits detection at some white dwarfs. The outstanding problem of persistent heavy metal abundances in white dwarfs is still far from being completely understood, and MIPS 24 micron measurements should go a long way to help address remaining questions by probing a large range of potential dust temperatures and, therefore, spatial distributions. We will also image with IRAC those white dwarfs (DZs mainly) which have not been probed at these shorter wavelengths. Some of the issues our science will address include: 1) the frequency of extrasolar planetary, cometary, and asteroidal systems around white dwarfs; 2) the long term evolution of such systems post main sequence; 3) the general origin of metals in white dwarfs but especially the frequency of debris disks among cool hydrogen- and helium-rich degenerates with heavy elements; 4) the temperature, origin, and spatial distribution of any material in white dwarf debris disks.

Spitzer Space Telescope - General Observer Proposal #50401

Completing the Autopsy of a Dead Spitzer Rock Star

Principal Investigator: Jay Farihi
Institution: UCLA

Technical Contact: Jay Farihi, UCLA

Co-Investigators:
Michael Jura, University of California, Los Angeles
Ben Zuckerman, University of California, Los Angeles
Beth Klein, University of California, Los Angeles

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 1.7

Abstract:
We propose to search the brightest disk-polluted white dwarf G29-38 at MIPS 70 um to directly test for a cold asteroid belt whose existence is inferred from successful modeling of its atmosphere and innermost circumstellar region. The metal-enriched photosphere and warm 2-24 um excess at G29-38 is well reproduced by a flat ring resulting from a tidally-disrupted minor planet perturbed into a close orbit. We construct a model of a surviving asteroid belt at 10 AU in which there is a 500 Myr accumulation of particles similar in nature to the solar zodiacal dust, which cannot be removed by drag forces at this low luminosity degenerate. Using this model, we predict a 70 um flux density of at least 2.4 mJy which should be detectable at the 4 sigma level in 1.7 hours of total telescope time.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #107

M17

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Lori Allen, Smithsonian Astrophysical Observatory

Science Category: circumstellar/debris disks
Observing Modes: IracMap
Hours Approved: 0.8

Abstract:
Massive star forming regions present spectacular views of several important astrophysical processes, from the emergence of rich clusters from dust-enshrouded cloud cores to the excitation and destruction of the surrounding interstellar medium. The Omega Nebula (M 17) is among the most active star forming regions in the sky, and contains one of the brightest HII regions in both optical and thermal wavelengths. Adjacent to the HII region lies an extremely massive dense molecular cloud core, containing more than 10^4 solar masses of material and an embedded infrared cluster. The complex structure of the ionized gas in the nebula was recently featured in a release of images from the Hubble Space Telescope/Advanced Camera for Surveys. The IRAC observations will highlight complementary structure in the optically dark, infrared bright, regions of M 17, in a dramatic demonstration of SIRTF's capability to 'lift the cosmic veil'.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #109

NGC 7129

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Judy Pipher, University of Rochester

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 2.6

Abstract:
We plan IRS observations of two mid-IR excess objects in the young cluster NGC 7129 in order to establish that we can identify disk gap objects solely on the basis of the combined IRAC and MIPS photometry. By establishing that the combined IRAC and MIPS SEDs are a reliable method for detecting disk gaps, we can examine how frequently gaps occur in our sample of 30 young stellar clusters, and assess whether giant planet formation commonly occurs in the first few million years.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #110

L1634 CLASS I

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Lori Allen, Smithsonian Astrophysical Observatory

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 0.4

Abstract:
We will obtain mid-IR spectra of two deeply embedded Class I protostars in the Lynds 1634 bright-rimmed cloud. These sources drive two outflows. With IRAC and MIPS data (both 24 and 70) already in hand and combined with extant submillimeter fluxes for both sources (Beltran et al. 2002), this is among the most complete high resolution and sensitive data set for protostars in the mid-IR. Using these data we will construct detailed models for these very young sources. The IRS spectra will be essential for understanding the roles of silicates and ices in the protostellar envelope, information that can not be accurately inferred from the broad band fluxes alone. We will compare the central source properties derived from the models with dynamical calculations for the outflows based on existing millimeter-wave molecular line maps (DeVries 2003).

Spitzer Space Telescope - Guaranteed Time Observer Proposal #112

IRAC and IRS Observations of RCW108

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Gary Melnick, Harvard-CfA

Science Category: circumstellar/debris disks
Observing Modes: IracMap IrsMap
Hours Approved: 0.9

Abstract:
RCW 108 is an Orion analog in the Southern Hemisphere. It is a site of high mass star formation that is heavily obscured at optical wavelengths. MSX images obtained at 8 micron with 20-arcsecond resolution hint at a complex underlying structure. Observations of RCW 108 with the Submillimeter Wave Astronomy Satellite (SWAS) reveal the 2nd strongest water emission line detected from any source in the Galaxy, after Orion BN/KL. The wavelength range of the IRS Long-High mode includes 8 water transitions with energies above the ground-sate of less than 900 K. These lines will be searched for to test for the presence of warm gas, such as might be expected from a shock.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #115

PDR Spectra

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Joseph Hora, Harvard/CfA

Science Category: circumstellar/debris disks
Observing Modes: IrsMap IrsStare
Hours Approved: 1.5

Abstract:
We will obtain small maps and pointed spectral observations of key locations in massive star-forming regions. The spectra will sample the broad emission features, atomic fine structure lines, and dust continuum emission in the 5-20 micron spectra. Spectra and images of the PDRs in the regions will be matched with models of macromolecular chemistry and PAH emission. The IRS spectra will allow us to determine important physical and evolutionary parameters for the PDRs, such as their UV flux, and gas and electron temperatures and densities. Comparison with synthesized spectra based on the chemical models will yield the distribution of the size and charge of the emitters.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #37

Disk Evolution in the Planet Formation Epoch

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Tom Megeath, Harvard, CfA

Science Category: circumstellar/debris disks
Observing Modes: IracMap MipsPhot MipsScan
Hours Approved: 49.7

Abstract:
The goal of this program is to trace the evolution of circumstellar disks around young stars through the likely epoch of planet formation at around 5-10 Myr. Disk spectral energy distributions will be used to determine the times of disk clearing as a function of radius, age, and stellar mass. IRAC and MIPS will be used to study circumstellar dust emission, with special emphasis on objects in the age range 3-10 Myr which are vastly underrepresented in current samples. Studies of nearby regions in Taurus and Chamaeleon I are included for comparison, along with objects in the nearby eta Cha and TW Hya associations.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40030

Circumstellar Debris Disks Around Nearby, Young M Dwarfs

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Center for Astrophysics

Technical Contact: Patrick Lowrance, Caltech

Co-Investigators:
Patrick Lowrance, Caltech/SSC
Massimo Marengo, Center for Astrophysics
David Ardila, Caltech/SSC

Science Category: circumstellar/debris disks
Observing Modes: IracMap MipsPhot
Hours Approved: 16.7

Abstract:
Planetary systems are currently believed to form within a circumstellar debris disk. Previous studies have identified over a hundred such debris disks around A, F, and G-type dwarfs from their thermal IR emission. However, very little is known about debris disks around M dwarfs, as only two debris disk systems around M dwarfs have been confirmed. Even though they are the most populous stars in our solar neighborhood, M dwarfs are often overlooked because of instrumental sensitivity; these low-mass stars have low luminosities and temperatures. But, if forming planetary systems exist around these stars, they would be the most numerous and represent a population worth examining. We propose to use the extraordinary sensitvity provided by MIPS on Spitzer to search for debris disks around a sample of nine young (~100Myr), nearby M dwarfs. The exposure times have been chosen to measure the photosphere from 3-70um. Based on current estimates of disk fractions, we should discover 1-2 debris disks, which will almost double the number of disks known around low-mass stars. Since M dwarfs are most likely the most common host of planetary systems, comparing their debris disks to those around higher mass stars will shed light on the diversity of planetary architectures. Divisions: There is 0.6 hour total using IRAC, and 16.4 hrs total using MIPS.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #47

A MIPS Survey of the Orion L1641 and L1630 Molecular Clouds

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Tom Megeath, Harvard, CfA

Science Category: circumstellar/debris disks
Observing Modes: MipsScan
Hours Approved: 11.8

Abstract:
We plan MIPS observations of the Orion L1630 and L1641 clouds. In conjunction with IRAC imaging, we will obtain the spectral energy distribution of the entire Orion young star population from 3.6-70 um. These data will be used to study the evolution of circumstellar disks and envelopes during the first few million years of pre-main sequence evolution and survey the clouds for embedded protostars.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50740

Exploring Dwarf Carbon Stars: Do They Really Have Disks?

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Patrick Lowrance, SSC/Caltech

Co-Investigators:
Patrick Lowrance, Caltech

Science Category: circumstellar/debris disks
Observing Modes: IracMap MipsPhot
Hours Approved: 11.5

Abstract:
With the discovery of G77-61 (Dahn et al. 1977) at a mere 58 pc and therefore relatively low luminosity, a category of dwarf carbon (dC) stars was finally recognized.This, however, presented a puzzle because a low mass star is incapable of the helium fusion needed to create carbon. A reolution was proposed and generally accepted a second member of a system could 'dump' carbon on it through an AGB stage. Current understanding of the formation and evolution of dC's is, however, limited by the small number of objects and observations. We propose observations of each carbon dwarf with IRAC, MIPS 24um, and MIPS 70um to attempt to detect a redsidual debris disk from such an event. The proposed model for creating carbon dwarfs is based on three objects and the mechanism for dumping material on these low-mass stars and building debris systems are currently unexplored. Thus the opportunity afforded by our program to add observational proof is valuable, especially for the very ill-studied carbon dwarfs. Only Spitzer can provide the spectral range and sensitivity to gain the observations needed in understanding disk formation and dissipation timescales around all evolved stars placing carbon in our ISM - a building block of life as we know it.

Spitzer Space Telescope - General Observer Proposal #50076

Testing a flare origin of crystalline silicates in protoplanetary disks

Principal Investigator: Eric Feigelson
Institution: Pennsylvania State University

Technical Contact: Eric Feigelson, Pennsylvania State University

Co-Investigators:
Jeroen Bouwman, Max Planck Institut fur Astronomie (Heidelberg)
Kevin Luhman, Pennsylvania State University
Konstantin Getman, Pennsylvania State University

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 3.8

Abstract:
Infrared spectroscopy with the Spitzer Space Telescope has revealed the rich chemistry of the dust present in protoplanetary disks. Of particular importance for understanding the evolution of the dust are crystalline silicates; high temperature condensates which formed in the protoplanetary disks and which can also be observed in ancient primitive Solar System bodies. At present, it is not clear which of several possible processes are responsible for their formation: gas-phase condensation or slow thermal melting in the hot inner disks, a variety of disk shock mechanisms, or magnetic reconnection flaring. Here we propose a study to investigate the role of a possible key formation mechanism: X-ray flaring. X-ray astronomical studies have demonstrated that strong and frequent magnetic flares are ubiquitous in pre-main sequence stars, and evidence is growing that the stellar X-rays efficiently irradiate the surrounding disks. It is thus a tempting explanation for grain annealing. We propose a critical test of this model by obtaining Spitzer IRS spectra of 13 star-disk systems in several nearby young stellar clusters, chosen specifically for unusually high levels of magnetic flaring with log Lx ~ 31 erg/s. These stars lie in the top 1% of the X-ray luminosity function of young stars and have not been well observed in previous IRS studies. If X-ray flaring is important, our proposed observations will show that a larger fraction of these disks will have crystalline silicates compared to existing disk samples with similar ages and stellar properties.

Spitzer Space Telescope - General Observer Proposal #50378

IRS Spectroscopy of Debris Disks Discovered by AKARI/IRC

Principal Investigator: Hideaki Fujiwara
Institution: University of Tokyo

Technical Contact: Hideaki Fujiwara, University of Tokyo

Co-Investigators:
Misato Fukagawa, Nagoya Univ.
Daisuke Ishihara, ISAS/JAXA
Hiroshi Murakami, ISAS/JAXA
Takanori Hirao, ISAS/JAXA
Keigo Enya, ISAS/JAXA
Takafumi Ootsubo, Nagoya Univ.
Munetaka Ueno, Univ. of Tokyo
Takuya Yamashita, Hiroshima Univ.
Takao Nakawaga, ISAS/JAXA
Takashi Onaka, Univ. of Tokyo
Hirokazu Kataza, ISAS/JAXA
Glenn White, Open Univ.
Jonathan Marshall, Open Univ.

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 4.3

Abstract:
It is very important to investigate the properties and spatial distribution of dust in debris disks to discuss the planet formation process. We have discovered 9 new debris disk candidates that show large 20 micron excess from the AKARI/IRC mid-infrared all-sky survey and pointed observations. Here we propose mid-infrared follow-up observations to reveal detailed spatial distribution and properties of the dust in the debris disks candidates with Spitzer/IRS. We investigate dust temperatures and spatial distributions of dust disk from the obtained mid-infrared spectral energy distributions of the excess. From the shapes, peak positions, and bandwidths of the dust features in the obtained spectra, we investigate dust properties, which may provide us some hints about the origin of dust in debris disks.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #123

Young PMS Stars

Principal Investigator: Robert Gehrz
Institution: University of Minnesota

Technical Contact: Elisha Polomski, University of Minnesota

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 5.5

Abstract:
We will obtain MIPS observations of young PMS stars to determine the structure and composition of their circumstellar environment.

Spitzer Space Telescope - Archive Research Proposal #50718

Modeling Gas Emission Lines from Circumstellar Disks

Principal Investigator: Uma Gorti
Institution: NASA Ames Research Center

Technical Contact: Uma Gorti, NASA Ames Research Center

Co-Investigators:
David Hollenbach, NASA Ames Research Center
Joan Najita, NOAO
Ilaria Pascucci, University of Arizona, Tucson

Science Category: circumstellar/debris disks
Dollars Approved: 75000.0

Abstract:
We propose an archival Spitzer data analysis and theoretical modeling of a sample of 4 circumstellar disks (Sz 102, XX Cha, T Cha, HD 132947), with conclusive evidence for the presence of gas in the $1-20$ AU region as probed by the Spitzer IRS. We will compare our sophisticated thermo- chemical disk models to observed line emission and upper limits from Spitzer IRS archival data. Our disks have detections of H_2, [NeII] and [FeI] lines and we will use our models to interpret this data and upper limits on other expected strong transitions such as H_2O, [FeII], [SiII], [SI] and OH lines. Inferred disk and stellar properties will include disk geometry (flaring or flat), dust/gas ratio, the strength and hardness of the Extreme UltraViolet stellar radiation field, disk gas mass, chemistry and distribution in the planet-forming regions of these disks.

Spitzer Space Telescope - General Observer Proposal #3657

Exploring a newly discovered debris disk: Gas content and dust mineralogy during the epoch of planet formation.

Principal Investigator: James Graham
Institution: University of California

Technical Contact: James Graham, University of California

Co-Investigators:
Paul Kalas, University of California, Berkeley
Brenda Matthews, University of California, Berkeley
Michael Liu, Institute for Astronomy, University of Hawaii

Science Category: circumstellar/debris disks
Observing Modes: IrsStare MipsPhot MipsSed
Hours Approved: 23.6

Abstract:
We propose a comprehensive Spitzer study of a newly discovered debris disk around the M0V star AU Microscopium (GJ 803). AU Mic is a nearby (9.9 pc) member of the Beta Pic moving group, with age 8-20 Myr. This system is unique as it is currently the only known spatially resolved M dwarf debris disk. Recent optical coronagraph observations reveal the existence of a spatially resolved, nearly edge-on dust disk similar to that of beta Pic, but with approximately one third the dust mass. A sub-mm detection at 850 microns confirms the presence of cool dust. Our Spitzer observations will yield the first infrared spectra of dust and gas in a M-dwarf debris disk. AU Mic is a common M0 dwarf, unlike beta Pic, Vega or Fomalhaut, which are A stars, so that observations of its disk may provide better insight to how the majority of planetary systems form and evolve. Our main goals are to use IRS to determine the warm gas content and excitation by directly searching for the pure rotational S(0), S(1) and S(2) lines of H2, and to measure the abundances of minerals from solid state features. The youth of AU Mic makes it an exciting target because Spitzer may witness the planet building process at work in this system. Moreover, our proposed observations will closely match the Spitzer GTO studies of the coeval beta Pictoris system. Together with the beta Pic dataset, our proposed AU Mic observations will permit a comparative study of how the circumstellar environment evolves different around two stars that originate from the same natal cloud.

Spitzer Space Telescope - General Observer Proposal #30339

Forming the first planetary systems

Principal Investigator: Jane Greaves
Institution: University of St Andrews

Technical Contact: Jane Greaves, University of St Andrews

Co-Investigators:
Debra Fischer, SFSU
Mark Wyatt, Cambridge University
Charles Beichman, Caltech
Geoff Bryden, JPL

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 6.5

Abstract:
Spitzer has discovered large numbers of debris disk systems, clarifying their relation to stellar age, spectral type, presence of Doppler planets, etc. Here we propose to search an uninvestigated sample of stars for debris: the nearby old Galactic stars that formed in the thick disk. These represent the earliest generations of stars in our Galaxy, and are characterised by low metals and perturbed orbits. Could these stars have formed planetary systems? The presence of debris is an indicator that bodies formed at least up to a few kilometres in size, and most of disk SED's support central clearing by a planet orbiting outside ~10 AU. We wish to test two contrasting hypotheses: that such early stars had inefficient planetesimal growth (0 detections expected), or that low metal content promotes slow-growing debris-and-outer-planet systems (high detection rate, ~5/15 stars). As well as clarifying the physics of planet-core formation, this project has astrobiological implications for the production of the earliest rocky planets of the Galaxy.

Spitzer Space Telescope - General Observer Proposal #40310

The composition of debris around HD 12039: water from asteroids?

Principal Investigator: Jane Greaves
Institution: University of St Andrews

Technical Contact: Jane Greaves, University of St Andrews

Co-Investigators:
Mark Wyatt, University of Cambridge
Casey Lisse, John Hopkins University
Helen Fraser, University of Strathclyde

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 5.2

Abstract:
A small number of nearby Sun-like stars possess warm dust belts, made from the debris of collisions within an analogue to the Sun's Asteroid Belt. Our analysis shows that the debris around the 30 Myr-old star HD 12039 could result from a *single* event, the breakup of a planetesimal ~100 km in size. This offers a unique opportunity to study the ejecta, and compare the composition to that of Solar System asteroids - in particular, the ejecta of comet 9P/Tempel 1 observed by Spitzer in the Deep Impact experiment. We wish to determine the derbis composition around HD 12039 and see what it would contribute if added to a growing terrestrial planet - in particular, whether asteroidal water could add to oceans of an 'exo-Earth'.

Spitzer Space Telescope - Archive Research Proposal #40809

Extending the Timeline for Angular Momentum Evolution: What Role Do Disks Play in Regulating Stellar Rotation at 5 Myr?

Principal Investigator: Catrina Hamilton-Drager
Institution: Dickinson College

Technical Contact: Catrina Hamilton-Drager, Dickinson College

Co-Investigators:
Christopher Johns-Krull, Rice University

Science Category: circumstellar/debris disks
Dollars Approved: 53525.0

Abstract:
A long-standing question in the theory of star formation has been the evolution of angular momentum. Most mechanisms employed to disperse the angular momentum have involved magnetic breaking in some way. In particular, a magnetic interaction between stellar magnetospheres and circumstellar disks, known as "disk-locking," is believed to cause the spin down of stars during the pre-main sequence (PMS) evolutionary stage. A key testable prediction of the disk-locking theory is that stars with longer rotation periods are more likely than those with short periods to have infrared excesses, indicating the presence of a circumstellar disk. We propose here to test this prediction in the young cluster NGC 2362 (age ~ 5 Myr). But at what age do stars typically decouple from their disks and begin to spin up, conserving angular momentum as they do? We will use archival IRAC flux measurements together with rotation periods that we have determined for PMS stars in this cluster to search for a correlation between mid-IR excess and rotation. We expect that there will be a lower fraction of slowly rotating stars lacking disks, as those stars that may have just been released from their disks at the age of Orion (t ~ 1 Myr), will have had time to spin up by 5 Myr. Additionally, we intend to use the Halpha emission line measurements of the stars in NGC 2362 to assess the evidence for ongoing accretion. If it is found that some of these stars are in fact still accreting gas while maintaining a mid-IR excess, our observations can constrain the timescale for the dispersal of inner disk regions, and provide critical insight to the formation mechanism of Jovian-like planets with orbital radii of less than 1 AU. With its estimated age near the empirically derived disk lifetime limit, our observations can also constrain the timescale for disk-locking by comparing them to the results seen in Orion (age ~ 1 Myr) and NGC 2264 (age ~ 2 Myr).

Spitzer Space Telescope - General Observer Proposal #20063

Super-Resolution 70 Micron Mapping of the Dust Around Young Stars in Serpens

Principal Investigator: Paul Harvey
Institution: University of Texas

Technical Contact: Paul Harvey, University of Texas

Co-Investigators:
Deborah Padgett, SSC
Phillip Myers, Harvard-CfA
Neal Evans, U. Texas

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 8.7

Abstract:
We propose to use the 70 micron fine scale super-resolution mode with MIPS to determine the luminosities and surrounding dust cloud structure of a cluster of newly found far-ir sources in the Serpens star-forming region, as well as for the very extended dust cloud surrounding the Herbig Ae/Be star VV Ser. Observations taken as part of the c2d ("Cores To Planet-Forming Disks") Spitzer Legacy Program have revealed a cluster of young stellar objects that are strong sources of emission longward of 10 um. We plan to model the dust cloud structure and luminosity of these objects in order to understand their evolutionary status and their relationship to the surrounding dust and gas. Because of the high density of objects of comparable brightness in this cluster, we require the highest possible angular resolution in the far-ir to separate their individual emission. The other part of this project involves similar mapping of the dust around a single young star, VV Ser, that has been observed in the c2d data to have a very extended, diffuse dust cloud around it. The cloud is well resolved in the 5 - 24um spectral region in the c2d data, but is poorly sampled and with low S/N at 70um and especially at 160um. For this object we propose to obtain both fine scale 70um imaging and 160um imaging.

Spitzer Space Telescope - General Observer Proposal #50799

Irradiated Disks around accreting brown dwarfs

Principal Investigator: Gregory Herczeg
Institution: California Institute of Technology

Technical Contact: Gregory Herczeg, California Institute of Technology

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 18.9

Abstract:
The growth and orbits of planets may be partially determined by the level of disk ionization caused by EUV and X-ray emission from the central star. However, until recently the ionized layer of the disk surface was difficult to study because of a lack of observational diagnostics. [Ne II] emission at 12.8 microns may be a powerful probe of the irradiated disk surface, and possibly a photoevaporative region if present. To date, surveys for [Ne II] have been restricted to stars with >0.3 M_sun. I propose to look for [Ne II] emission from a sample of 10 accreting brown dwarfs and very low-mass stars. Measuring the flux in the [Ne II] line at such low masses would help to constrain disk irradiation models for a larger range of mass and mass accretion rate than is currently possible.

Spitzer Space Telescope - General Observer Proposal #50675

Disk census in NGC2169: the final phase of primordial disks

Principal Investigator: Jesus Hernandez
Institution: University of Michigan

Technical Contact: Jesus Hernandez, University of Michigan

Co-Investigators:
Nuria Calvet, University of Michigan
Rob Jeffries, Keele University
James Muzerolle, University of Arizona

Science Category: circumstellar/debris disks
Observing Modes: IracMap MipsScan
Hours Approved: 6.4

Abstract:
The goal of this program is study the disk population in the open stellar cluster NGC2169 using IRAC and deep 24mic MIPS observations. NGC2169 is a well characterized cluster located at 1Kpc and with stellar age of 9+-2 Myr. Stellar groups at 10Myr represent a crucial age in disk evolution, where mostly primordial disks have been dissipated and second generation dusty disks are more frequent and luminous. So far, only few 10Myr old stellar groups have been observed by Spitzer, in addition, NGC2169 is more populous than those stellar groups. Analysis of IRAC / deep MIPS observations of NGC2169 will provide an unprecedent disks census of primordial disks at the final phase of primordial disk dissipation, and debris disks around solar-type stars and intermediate mass stars at the first stages of the second generation dusty disks.

Spitzer Space Telescope - General Observer Proposal #50690

Young debris disks at the epoch of planet formation in the Orion OB1 association

Principal Investigator: Jesus Hernandez
Institution: University of Michigan

Technical Contact: Jesus Hernandez, University of Michigan

Co-Investigators:
Nuria Calvet, University of Michigan
Lee Hartmann, University of Michigan
Cesar Briceno, Centro de Investigaciones de Astronomia
Paola DAlessio, UNAM
James Muzerolle, Steward Observatory, University of Arizona
Christine Chen, NOAO

Science Category: circumstellar/debris disks
Observing Modes: IrsStare MipsPhot
Hours Approved: 24.0

Abstract:
Debris disks are dusty, gas-poor disks around stars, in which the grains are replenished from a reservoir, such as collisions between parents bodies. In general, observational studies of the evolution of Debris disks have been focused on long period trend (from few Myr to hundred of Myr or Gyr), where the luminosities of the debris disks decay as the reservoir of collisional parent diminishes. However, theoretical models show that for A type the time scale to produce large icy objects (1000 Km) that stir-up the solids on the disks and begin a collisional cascade is around 10 Myr, observational studies on the Orion OB1 association support this timescale showing that the debris disks around intermediate mass stars are more frequent and have larger 24{micron} excess around 10 Myr (the stellar aggregate 25 Ori); younger stellar groups could be associated to a phase between the clearing of primordial disks ($<$3My) and the formation of large icy object. We propose to obtain IRS spectra (short-low and long-low modules) and 70{micron} MIPS photometry in order to study in more detail 18 debris disk found in three region of the Orion Association: the stellar aggregate 25 Ori (10 Myr), the sub association Orion OB1b (5 Myr), and the stellar cluster $sigma$ Orionis (3 Myr). The analysis of the IRS spectra and the spectral energy distribution, in combination with theoretical models, will provide us important tools to characterize the bulk of the emitting particles (e.g. grain-size distribution, composition and radial distribution of dust); besides, 70 {micron} photometry enable us to study the outer part of the disk where mechanisms for dispersing primordial optically thick disks operate less efficiently. Overall, this project will provide considerable insight into the nature of the second generation dust process at the epoch of planet formation and primordial disk dissipation

Spitzer Space Telescope - General Observer Proposal #20548

Followup Observations of Newly Identified Debris Disks Associated with Solar-Mass Stars

Principal Investigator: Dean Hines
Institution: Space Science Institute

Technical Contact: Dean Hines, Space Science Institute

Co-Investigators:
Serena Kim, University of Arizona
Dana Backman, NASA Ames Research Center
John Carpenter, California Institute of Technology
Lynne Hillenbrand, California Institute of Technology
Michael Meyer, University of Arizona
Ilaria Pascucci, University of Arizona
Murray Silverstone, University of Arizona

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 25.0

Abstract:
We propose to obtain new 70 and 160 micron observations for a carefully selected sub-sample of debris systems around solar-mass stars from the Formation and Evolution of Planetary Systems (FEPS) Spitzer Legacy Science Program. The new data, complemented by planned millimeter observations from the ground will constrain: 1) the outer radii of disks detected as part of FEPS; and 2) the amount of cold dust in these regions. Our proposed 70 and 160 micron observations are crucial in order to compare dust from 30 - 100 AU in newly identified debris disk systems with evolutionary models of our own Kuiper Belt. Our ultimate goal, then, is to use these results to assess whether solar systems like our own are common or rare among sun-like stars in the disk of the Milky Way. Our enhanced spectral energy distributions, and the subsequent well constrained accompanying debris disk models, will further the FEPS science legacy by serving as templates for, and be complementary with, existing Spitzer data sets that have been acquired by other GTO and GO surveys of sun-like stars.

Spitzer Space Telescope - General Observer Proposal #30500

FEPS Follow-Up. II: MIPS Photometry

Principal Investigator: Dean Hines
Institution: Space Science Institute

Technical Contact: Dean Hines, Space Science Institute

Co-Investigators:
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Dana Backman, NASA Ames Research Center
John Carpenter, California Institute of Technology
Lynne Hillenbrand, California Institute of Technology
Michael Meyer, University of Arizona
Ilaria Pascucci, University of Arizona
Murray Silverstone, University of Arizona
Stanimir Metchev, UCLA
John Stauffer, California Institute of Technology

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 13.7

Abstract:
We propose to obtain new 70 and 160 micron photometric observations of a carefully selected sample of debris systems around sun-like stars identified during the Spitzer Legacy Science Program titled, the Formation and Evolution of Planetary Systems (FEPS). Our proposed Spitzer observations will complete the detailed follow-up characterization of FEPS-identified debris systems that began with our previously approved GO2 program. In GO3 we seek to extend the GO2 program to include the 19 additional debris systems that have been identified in the FEPS survey since its completion after the GO2 deadline. The proposed 70 and 160 micron observations are crucial in order to compare dust from 30 - 100 AU in newly identified debris disk systems with evolutionary models of our own Kuiper Belt. Our ultimate goal, then, is to use these results to assess whether solar systems like our own are common or rare among sun-like stars in the disk of the Milky Way. Our enhanced spectral energy distributions, and the subsequent well constrained accompanying debris disk models, will further the FEPS science legacy by serving as templates for, and be complementary with, existing Spitzer data sets that have been acquired by other GTO and GO surveys of sun-like stars.

Spitzer Space Telescope - General Observer Proposal #3580

Study of Far-Infrared Crystalline Silicate Features of Dust in Debris Disks and Protoplanetary Disks

Principal Investigator: Mitsuhiko Honda
Institution: Subaru Telescope / Univ. of Tokyo

Technical Contact: Mitsuhiko Honda, Subaru Telescope / Univ. of Tokyo

Co-Investigators:
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Shigeyuki Sako, Subaru Tlescope / Univ. of Tokyo
Takuya Fujiyoshi, Subaru Telescope
Yoko Okada, Univ. of Tokyo
Itsuki Sakon, Univ. of Tokyo
Takashi Onaka, Univ. of Tokyo

Science Category: circumstellar/debris disks
Observing Modes: IrsStare MipsSed
Hours Approved: 5.2

Abstract:
Recent studies of crystalline silicate around Herbig Ae/Be stars revealed that Mg-pure olivine (forsterite; Mg2SiO4) is present around these stars. On the other hand, silicate dust composition of T Tauri stars and Vega-like stars are not well constrained so far. We have been making ground-based 10 micron spectroscopic observations of T Tauri stars and Vega-like stars and found possible evidence for compositional evolution of dust around young stars, though verification using crystalline silicate features in longer wavelengths is strongly desired. Here we propose to make SST observations of these stars which show crystalline silicate features in 10 micron band to confirm dust compositional evolution around young stars. We are expecting to establish crystalline silicate dust evolution around young stars and it would provide us a clue to understand what is occuring in the disk to promote such dust compositional evolution.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #2

Spectroscopy of protostellar, protoplanetary and debris disks

Principal Investigator: James R. Houck
Institution: Cornell University

Technical Contact: Dan Watson, University of Rochester

Science Category: circumstellar/debris disks
Observing Modes: IrsMap IrsStare MipsSed
Hours Approved: 167.0

Abstract:
SIRTF, and the IRS in particular, is sensitive to the crucial region for protostellar disk accretion, jet collimation and planetary formation, between a few hundredths and a few tens of AU from the central objects. We will exploit this feature of SIRTF-IRS in an exploration the evolution of circumstellar disks, from star birth, through the epoch of the clearing of the terrestrial-planet region and the formation of planets, and toward the end of stellar main-sequence lives. For this purpose we have selected a sample of some 600 objects, in nearby regions of current star formation, in open clusters of well-determined, intermediate age (3-100 Myr), and in lists of main-sequence stars with infrared excesses. Along with the range of ages we have taken care to cover variation in disk orientation, stellar multiplicity, and cluster richness, and have opted to cover relatively uniformly the stellar mass function down to (slightly past) the hydrogen-burning limit. We will observe each object in this sample over the whole IRS spectral range (5-40 microns). The low-resolution spectrographs will be used except for the brightest ~25% of the sample; for these latter objects the IRS high-resolution modules will be used instead of the Long Lo spectrograph. Among the spectral features we will see will be short-wavelength continuum "dropouts" due to inner-disk clearing; signatures of crystalline solids, developing in strength as dust grains are processed in the disk; and molecular, atomic and ionic lines from accretion shocks, jets, and outflow shocks.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40651

Characterizing Warm Debris Around Main Sequence Stars

Principal Investigator: James Houck
Institution: Cornell University

Technical Contact: Christine Chen, NOAO

Co-Investigators:
Dan Watson, University of Rochester
Bill Forrest, University of Rochester
Christine Chen, NOAO
Michael Jura, UCLA
Nuria Calvet, U. MIchigan
Paola d'Alessio, UNAM-Morelia
Elise Furlan, UCLA
Lee Hartmann, U. Michigan
Luke Keller, Ithaca College
Ciska Markwick-Kemper, U. Manchester
Joan Najita, NOAO
Greg Sloan, Cornell U

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 21.4

Abstract:
We propose to obtain Spitzer IRS spectroscopy of 104 main-sequence stars with infrared excess detected with SpitzerMIPS or IRAS. 74 objects possess MIPS 24 micron or IRAS 25 micron excess generated by warm dust with temperatures (T~230 K) similar to that found in our asteroid belt. IRS spectroscopy is needed to measure the 5 - 35 micron spectral energy distribution (SED), to constrain the spatial distribution of the dust and to search for solid state emission features that may reveal grain composition. 30 of our targets have MIPS 70 micron or IRAS 60 micron excess, but no evident shorter wavelength excess. Are there detectable differences between dust produced from cold reservoirs (analogous to the Kuiper belt) and dust produced from warm reservoirs (analogous to the asteroid belt). We propose to double the number warm-dust systems observed with SpitzerIRS and increases the total number of debris disks observed by ~40%.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50053

Completing the IRS Survey of Disks in Taurus and Chamaeleon

Principal Investigator: James R. Houck
Institution: Cornell University

Technical Contact: Kevin Luhman, Pennsylvania State University

Co-Investigators:
Kevin Luhman, Pennsylvania State University
Dan Watson, University of Rochester
Bill Forrest, University of Rochester
Nuria Calvet, University of Michigan
Lee Hartmann, University of Michigan
Elise Furlan, UCLA/NAI
Paola D'Alessio, UNAM
Greg Sloan, Cornell University

Science Category: circumstellar/debris disks
Observing Modes: IracMap IrsStare
Hours Approved: 28.7

Abstract:
During the first four years of Spitzer's mission, we have conducted a comprehensive IRS survey of disks around stars and brown dwarfs in nearby star-forming regions through the IRS GTO program. We are using these data to study several aspects of circumstellar disks and planet formation, including the settling, composition, size distribution, and crystallization fraction of dust and the presence of gaps and inner holes. The two primary cornerstones of this survey are Taurus and Chamaeleon I, which are the two nearest and best-studied star-forming regions. We propose to obtain IRS spectra of all of the remaining disk-bearing stars and brown dwarfs in these regions that have not been observed with IRS. With the completion of this program, Taurus and Chamaeleon I will be the most thoroughly surveyed star-forming regions with IRS.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50485

The Diversity of Intermediate-age Transitional Disks

Principal Investigator: James R. Houck
Institution: Cornell University

Technical Contact: Dan Watson, University of Rochester

Co-Investigators:
Nuria Calvet, University of Michigan
Christine Chen, NOAO
Paola D'Alessio, UNAM
Catherine Espaillat, University of Michigan
Elise Furlan, UCLA
William Forrest, University of Rochester
Lee Hartmann, University of Michigan
Jesus Hernandez, University of Michigan
James Muzerolle, University of Arizona
Ben Sargent, University of Rochester
Dan Watson, University of Rochester

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 20.9

Abstract:
The details of how disk material evolves from an initially well-mixed distribution of gas and dust to a system composed mostly of large solids and gas giants like our own solar system is not well understood and is a fundamental question in astronomy. Theory suggests that as time passes grains in the disk collide and stick and then settle towards the dense disk midplane, eventually growing in size and forming planets and that this process is fastest in the inner, planet-forming regions of the disk. In the past few years the Spitzer IRS instrument has greatly aided in studying these regions of the disk by giving us extraordinary coverage in the mid-infrared. Some of the most notable observations with Spitzer have been of stars with optically-thick outer disks but inner disks which have undergone significant clearing and have inner disk holes that are mostly devoid of dust i.e. the ''transitional disks.'' Despite this revolutionary progress, however, the time scales of disk dissipation are not well-constrained. This is because previous Spitzer studies of transitional disks have focused on young 1-2 Myr old star-forming clouds. As such, we lack a coherent study of disk dissipation in older disks, hindering our ability to study how disk clearing correlates with age. Here we propose to obtain low-resolution IRS spectra of transitional disks in star-forming regions in the neglected time range of 3-20 Myr. This proposed study will give us a complete survey of transitional disks around stars up to 20 Myr and will set the stage for future observations with ALMA and JWST.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50498

Probing the Nature of Transition Objects: Spectroscopy of the Gaseous Disk

Principal Investigator: James R. Houck
Institution: Cornell University

Technical Contact: Dan Watson, University of Rochester

Co-Investigators:
Joan Najita, NOAO
Elise Furlan, UCLA/NAI
John Carr, Naval Research Laboratory
Catherine Espaillat, University of Michigan

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 21.7

Abstract:
As disk systems in which planet formation may be under way, transition objects offer the potential for unique insights on the planet formation process. For transition objects with known stellar ages, determining if these systems are forming planets and what stage of planet formation they are in can place fundamental constraints on planet formation timescales. The nature of transition objects is, in fact, controversial. Their SEDs, which probe the radial distribution of dust in the disk, have been variously explained as the result of disk photoevaporation, grain growth, or the formation of a Jovian or larger mass planet. Complementary information, such as the radial distribution of the gaseous disk, can distinguish between these possibilities. We therefore propose IRS spectroscopy that will characterize the gaseous disks of transition objects. Our proposal capitalizes on recent Spitzer results which demonstrate dramatic progress in our ability to probe the gaseous component of disks. By comparing the molecular line emission properties of transition objects with those of a comparison sample of T Tauri stars, we will probe empirically the evolutionary state of these systems.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #95

IRS observations of Spatially Extended Vega-type Dust Disks

Principal Investigator: James R. Houck
Institution: Cornell University

Technical Contact: Jeffrey Van Cleve, Ball Aerospace

Science Category: circumstellar/debris disks
Observing Modes: IrsMap IrsStare
Hours Approved: 4.1

Abstract:
We collect high S/N spectra of 9 main-sequence stars with significant IR excesses at 25 um, which may have spatially resolvable dust disks, in order to study the temperature and compositional profiles of these disks. The same source list is being used by MIPS in their co-ordinated study. This study uses all IRS modules, and uses the Long Lo 1st order aperture in a step and stare study of spatial extent.

Spitzer Space Telescope - General Observer Proposal #40127

Characterization of the Dust Environment in and around WZ Sge

Principal Investigator: Steve Howell
Institution: WIYN Observatory

Technical Contact: Steve Howell, WIYN Observatory

Co-Investigators:
Donald Hoard, Spitzer Science Center
Carolyn Brinkworth, Spitzer Science Center
David Ciardi, Michelson Science Center
Paula Szkody, University of Washington

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 3.6

Abstract:
Accretion disks are ubiquitous in astronomy, providing the driving mechanism for such phenomena as the tremendous energy output from AGN and the production of planets around a parent star. Accretion disks are generally grouped as cold or hot: proto-stellar disks, with temperatures of 5000K or less, and accretion disks in interacting binaries and AGN with temperatures in excess of 5000K. Recently, new near-IR spectroscopic observations of the interacting binary WZ Sge have revealed, for the first time, a system that may span the two types of astrophysical disks. Strong H and He emission lines and an optically blue continuum provide evidence for hot disk regions of temperature 5000-10,000K. Our new discovery of molecular emission indicates that the binary also contains cool, dusty regions with T=2000-3000K or less. The environs of WZ Sge provide the only known laboratory in which both a hot and a cold disk exist simultaneously. We propose to use Spitzer to understand the source and physics of the cold material, the molecular content, and the dust conditions present in WZ Sge.

Spitzer Space Telescope - Directors Discretionary Time Proposal #479

Spitzer Light Curve of Z Cha

Principal Investigator: Steve Howell
Institution: NOAO

Technical Contact: Donald Hoard, SSC

Co-Investigators:
Donald Hoard, SSC

Science Category: circumstellar/debris disks
Observing Modes: IracMap
Hours Approved: 2.0

Abstract:
Using Spitzer Space Telescope observations of the interacting binary WZ Sge, we have discovered that the accretion disk is far more complex than previously thought. Our IRAC channel 2 and 4 time series observations reveal that the size of the accretion disk is far greater then currently believed and modeled (based on optical and UV observations) over the past few decades. Our preliminary findings suggest that the accretion disk contains a large, cool outer dust ring likely to extend to far greater radius than currently believed. These observations have great relevance for accretion disks in general, those in binary systems as well as in active galaxies. This new Spitzer/NOAO Research Program for Teachers and Students proposal will provide observations of the eclipsing dwarf nova Z Cha that will test and confirm our new findings, as well as provide the basis for additional classroom and EPO activities related to infrared astronomy, eclipsing binary stars, and the process of mass transfer/accretion.

Spitzer Space Telescope - General Observer Proposal #30409

Evolution and Structure of Very Low Mass Disks Around YSOs

Principal Investigator: Daniel Jaffe
Institution: University of Texas

Technical Contact: Katelyn Allers, Institute for Astronomy

Co-Investigators:
Katelyn Allers, University of Hawaii
Bruno Merin, Leiden Observatory
Jacqueline Kessler-Silacci, University of Texas

Science Category: circumstellar/debris disks
Observing Modes: IrsPeakupImage IrsStare
Hours Approved: 22.0

Abstract:
We propose to study the structure and chemistry of disks around young brown dwarfs with very low masses. With the addition of our lowest mass sources, detailed spectral information will be available for dust disks around objects ranging from below the deuterium burning limit to massive HAEBE stars. The new results will help us understand disk physics and the planet formation process by telling us about behavior in an environment where gravitational and radiative influences are very different from those around solar mass stars. We have used data from the Spitzer c2d Legacy survey and a deep IJHK survey to develop a sample of young, low mass (down to 6 MJupiter) brown dwarfs with disks. We have, or will have shortly, the luminosity and spectral type for each source, as well as the spatial distribution of the sample and knowledge of the interstellar environment. With the IRS data we seek to take, we will extend our knowledge of the disk properties by using radiative transfer models to determine the extent of flaring, the size of the inner hole, and the size, composition and location of the emitting grains. We will use this information to test ideas about the relationship between disk structure and the chemical evolution of the dust.

Spitzer Space Telescope - General Observer Proposal #40601

Debris disks at the epoch of terrestrial planet formation

Principal Investigator: Robin Jeffries
Institution: Keele University

Technical Contact: Robin Jeffries, Keele University

Co-Investigators:
Joana Oliveira, Keele University

Science Category: circumstellar/debris disks
Observing Modes: IracMap MipsScan
Hours Approved: 14.7

Abstract:
We propose Spitzer near- and mid-IR (24 micron) observations of 50 solar-type stars in the young open cluster IC 4665 (age 27 +/- 5 Myr). Current models for the assembly of terrestrial planets by the merging and collision of planitesimals and planetary embryos predict substantial dust debris disks at 0.5-3 AU around solar-type stars, that radiate strongly at 24 microns. We will search for the frequency and strength of this signature and assess the diversity of debris disk properties at an epoch during which our own Earth-Moon system was being formed. The distribution of mid-IR excesses will depend on the frequency with which ~1000 km planetary embryos collide and the speed at which dust is cleared from the system. The ultimate aim of such research is to understand whether the architecture of our Sun’s terrestrial planetary system is a common outcome of the star and planetary formation process. IC 4665 fills an important age-gap in our empirical knowledge of debris-disk evolution -- the epoch in which planetary embryo collisions may be at a maximum. Our modest proposed IRAC/MIPS survey can search for debris-disks around a similar sized (and chemically homogeneous) sample to that contained in the entire FEPS legacy program with ages 10-50 Myr.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #84

A Search for Terrestrial Planetary Debris Systems and Other Planetary Debris Disks

Principal Investigator: Michael Jura
Institution: University of California - Los Angeles

Technical Contact: Michael Jura, University of California - Los Angeles

Science Category: circumstellar/debris disks
Observing Modes: IracMap IrsStare MipsPhot MipsSed
Hours Approved: 28.8

Abstract:
MIPS photometry will be obtained for a large sample of young, relatively nearby (generally within 100 pc) stars. The primary objectives of this program are: 1) identify systems possessing warm dust emission analogous to the zodiacal bands of the inner solar system, 2) find further examples of the pre-main-sequence planetary debris system (PDS) discovered for HD 98800B, and 3) identify Vega-type cooler dust excesses early in the evolution of their illuminating stars. This survey will constrain models of the origin and evolution of PDSs with the ultimate goal of determining how often, and in what circumstances terrestrial planets are formed. In addition, the survey will identify objects having mid-IR excesses that will be suitable targets for follow-up ground- and space-based observations at higher resolution. This program is a collaboration among four SIRTF GTOs (F. Low, M. Werner, M. Jura, and R. Gehrz). Each GTO will will submit his portion of the observational program separately.

Spitzer Space Telescope - Directors Discretionary Time Proposal #275

Probing DAZ White Dwarfs for Warm and Cool Dust

Principal Investigator: Michael Jura
Institution: University of California - Los Angeles

Technical Contact: Jay Farihi, Gemini Operations North

Science Category: Circumstellar/Debris Disks
Observing Modes: IracMap MipsPhot
Hours Approved: 11.1

Abstract:
We propose IRAC and MIPS 24 micron imaging for a sample of nearby very metal-rich white dwarfs in order to detect excess emission due to relatively cool dust. The main science goal is to further explore the connection between debris disks orbiting white dwarfs with photospheric metals by probing their circumstellar environments, with unprecedented sensitivity, for cool dust. Our target sample includes both hydrogen-rich degenerates with metals (spectral type DAZ). Recent surveys, including ongoing work by our team, have discovered a few white dwarfs with evidence for warm dust via excess emission in the 2-8 micron region and there are reasons why we might expect that cooler dust awaits detection at some white dwarfs. The outstanding problem of persistent heavy metal abundances in white dwarfs is still far from being completely understood, and MIPS 24 micron measurements should go a long way to help address remaining questions by probing a large range of potential dust temperatures and, therefore, spatial distributions. We will also image with IRAC many white dwarfs which have not been probed at these shorter wavelengths. Some of the issues our science will address include: 1) the frequency of extrasolar planetary, cometary, and asteroidal systems around white dwarfs; 2) the long term evolution of such systems post main sequence; 3) the general origin of metals in white dwarfs but especially the frequency of debris disks among cool hydrogen-rich degenerates with heavy elements; 4) the temperature, origin, and spatial distribution of any material in white dwarf debris disks.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #10

Dust Around Main Sequence A-Type Stars

Principal Investigator: Michael Jura
Institution: University of California - Los Angeles

Technical Contact: Michael Jura, University of California - Los Angeles

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 24.0

Abstract:
We propose to use MIPS to search for dust around a well defined sample of nearby A-type main sequence stars. Our selection criteria are: (1) the have distances measured by Hipparcos data of less than 80 pc (2) 0.0 > (B-V) > 0.2 mag and (3) M(V) > 1.0 + 5.5 (B-V). These stars mostly have ages less than 100 million years and may still display circumstellar dust emission.

Spitzer Space Telescope - General Observer Proposal #40246

Infrared Spectra of Dust Orbiting Single White Dwarfs

Principal Investigator: Michael Jura
Institution: University of California, Los Angeles

Technical Contact: Jay Farihi, Gemini Observatory

Co-Investigators:
Jay Farihi, Gemini Observatory
Ben Zuckerman, University of California, Los Angeles
Eric Becklin, University of California, Los Angeles

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 10.0

Abstract:
We propose IRS observations of six single white dwarfs with an IRAC-detected infrared excess. We hope to determine, as found previously for G29-38 and GD 362, whether these six additional stars display silicate dust emission characteristic of pulverized asteroids rather than interstellar grains. If so, then the case will be strengthened that we can use the measured metal abundances in the photospheres of white dwarfs to determine the bulk composition of extra-solar minor planets.

Spitzer Space Telescope - General Observer Proposal #50060

A Focused Search for Circumstellar Dust Orbiting White Dwarfs

Principal Investigator: Michael Jura
Institution: University of California - Los Angeles

Technical Contact: Jay Farihi, UCLA

Co-Investigators:
Jay Farihi, University of California, Los Angeles
Ben Zuckerman, University of California, Los Angeles
Beth Klein, University of California, Los Angeles

Science Category: circumstellar/debris disks
Observing Modes: IracMap
Hours Approved: 4.7

Abstract:
Ten single metal-contaminated white dwarfs are known to possess an infrared excess; it is very likely that these stars are accreting tidally-disrupted asteroids. We propose to use 4.7 hours of telescope time with IRAC to search for an infrared excess around an additional 9 white dwarfs. Five hydrogen-rich targets are chosen because they are known to have unusually large metal accretion rates, and three helium-rich stars display a large amount of atmospheric calcium. One target is selected because it possesses substantially more atmospheric carbon than can be explained by conventional models. Is this star accreting from a tidally-disrupted carbon-rich minor planet?

Spitzer Space Telescope - Guaranteed Time Observer Proposal #7

Study of Dust Spectra of R Cor Bor Stars

Principal Investigator: Michael Jura
Institution: University of California - Los Angeles

Technical Contact: Michael Jura, University of California - Los Angeles

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 1.4

Abstract:
This program will study the dust spectra of R Cor Bor stars.

Spitzer Space Telescope - General Observer Proposal #50737

Sub-giants with planets: A MIPS survey for their Kuiper Belts

Principal Investigator: Paul Kalas
Institution: University of California, Berkeley

Technical Contact: Paul Kalas, University of California, Berkeley

Co-Investigators:
James Graham, University of California, Berkeley

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 5.7

Abstract:
A-star debris disks provided the first evidence that exoplanetary systems are common, and these hosts remain the best targets for detection of planetary debris. However, A stars are poor targets for precision Doppler studies, which focus on solar analogs. Consequently, progress from Spitzer in understanding the relationship between debris disks and exoplanets has been modest. Recently, evolved A-type stars (late G/early K subgiants) have been subjected to precision radial velocity measurements and we now know their A-type progenitor stars do host planets. This progress presents a new opportunity to quantify the relationship between debris disk properties and exoplanetary systems. We therefore propose a MIPS 24/70 micron survey of nine evolved stars with known exoplanets. Observations of an additional 30 subgiants in the SPITZER archive will provide the statistical context to interpret these results.

Spitzer Space Telescope - General Observer Proposal #30858

The Nature of the Dust around Lambda Bootis Stars: Debris Disks or Reflection Nebulae

Principal Investigator: Inga Kamp
Institution: ESA/STScI

Technical Contact: Inga Kamp, ESA/STScI

Co-Investigators:
Katherine Y.L. Su, Steward Observatory
Christine Chen, NOAO
Juan Rafael Martinez Galarza, Leiden Observatory
John Stansberry, Steward Observatory

Science Category: circumstellar/debris disks
Observing Modes: IracMap IrsMap
Hours Approved: 8.1

Abstract:
The group of lambda Bootis stars comprises late B- to early F-type, Population I stars with apparently solar abundances of C, N, O, and S as well as underabundances of the Fe-peak elements. Earlier investigations showed that the abundance pattern resembles much the depletion pattern found in the gas-phase of the interstellar medium, where refractory elements like iron and silicon have condensed into dust grains. Infrared measurements by IRAS, ISO and recently Spitzer (MIPS), indicate the presence of dust in the environment around the lambda Bootis stars. Kamp & Paunzen recently explained the lambda Bootis abundance pattern in the framework of a diffusion/accretion scenario, where the star passes through an interstellar cloud and accretes the metal-poor gas. Since SED modeling is inconclusive in distinguishing between disk emission and a reflection nebula, we propose to carry out infrared spectroscopy and imaging of 35 lambda Bootis stars to clarify the nature of the infrared excess around these stars: is the dust distributed in a circumstellar debris disk and thus linked to the formation of planetary systems, or is it interstellar material further out in a reflection nebulosity. We propose IRS mapping in low resolution mode and IRAC imaging to discriminate between these two scenarios and to possibly detect emission from polycyclic aromatic hydrocarbons - a common component of the interstellar medium - around lambda Bootis stars.

Spitzer Space Telescope - General Observer Proposal #30869

Supersized: A Spitzer Survey of Dusty Disks around B[e] Supergiants in the Magellanic Clouds

Principal Investigator: Joel Kastner
Institution: Rochester Institute of Technology

Technical Contact: Joel Kastner, Rochester Institute of Technology

Co-Investigators:
Catherine Buchanan, Rochester Inst. of Technology
Ben Sargent, University of Rochester
Bill Forrest, University of Rochester
Raghvendra Sahai, JPL

Science Category: circumstellar/debris disks
Observing Modes: IracMap IrsStare MipsPhot
Hours Approved: 15.3

Abstract:
The enigmatic class of B[e] super/hypergiants include among the most luminous individual stars known. These stars are of great interest and importance to the study of massive stars and their environments. Via Cycle 1 Spitzer IRS observations, we discovered that two Large Magellanic Cloud (LMC) B[e] hypergiants, R 126 and R 66, display similar, flat IR spectral enegy distributions indicative of the presence of massive, dusty circumstellar disks; R 66 displays, in addition, spectral evidence for crystalline grains and PAHs. This Spitzer/IRS discovery of ''fraternal twin'' disks around R 126 and R 66 has provided new insight into the origin and composition of dusty disks around the most massive stars. We now propose to build on these results via a comprehensive Spitzer IRS and photometric survey of thermal dust emission from a complete sample of all B[e] supergiants and hypergiants in the Magellanic Clouds. The IRS spectra and IRAC/MIPS photometry data will establish the fraction of B[e] supergiants that are encircled by dusty disks and, through modeling, will yield the range of masses, radii, and scale heights that characterize B[e] star dust disks. These results will provide crucial constraints on models of the origin of disks around massive stars , as well as on mechanisms for the production of crystalline silicate grains and for the shaping of supernova remnants.

Spitzer Space Telescope - Archive Research Proposal #50752

PAH emission from Herbig AeBe stars: Do hydrocarbons in proto-planetary disks have a unique aroma?

Principal Investigator: Luke Keller
Institution: Ithaca College

Technical Contact: Luke Keller, Ithaca College

Co-Investigators:
Greg Sloan, Cornell University

Science Category: circumstellar/debris disks
Dollars Approved: 25000.0

Abstract:
Over half of the intermediate-mass young stellar objects in the Galaxy (e.g. Herbig AeBe stars or HAeBe) have high-contrast emission in the mid-infrared spectral features of polycyclic aromatic hydrocarbons (PAHs) above the continuum produced by thermal emission from dust in the circumstellar disks. We have examined the PAH emission in detail for a sample of 19 HAeBe stars observed with the Spitzer IRS as part of the IRS Disks GTO program. Even with this relatively small sample, we have identified some trends that, should they survive in a larger sample of HAeBe stars, will allow us to infer large-scale disk geometry (both inner and outer) and the degree of photo-processing of organic molecular material in HAeBe disks. The bottom line of our work thus far is that HAeBe apparently have distinctive PAH spectra among the many other astronomical environments that are characterized by strong PAH emission. We therefore propose to apply our spectral analysis methods to an additional 57 HAeBe observed with the IRS and currently (or soon to be) available in the Spitzer archive. Our total sample of 76 HAeBe stars will allow closer scrutiny of the trends that we have identified in our empirical study and will also be the subject of a detailed disk modeling effort that will include the PAH emission.

Spitzer Space Telescope - General Observer Proposal #40690

MIPS 24 micron observations of h & chi Persei: debris disk evolution at 13 Myr

Principal Investigator: Scott Kenyon
Institution: Smithsonian Astrophysical Observatory

Technical Contact: Scott Kenyon, Smithsonian Astrophysical Observatory

Co-Investigators:
George Rieke, Steward Observatory
Thayne Currie, Smithsonian Astrophysical Observatory
Zoltan Balog, Steward Observatory
Peter Plavchan, IPAC
Benjamin Bromley, University of Utah

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 13.0

Abstract:
We propose to obtain 24 micron images of the 13 Myr-old Double Cluster h & chi Persei. The proposed observations will yield two 13' x 13' maps that include the half-density radius of each cluster. Our target sensitivity, 60 microJy ([24] = 12.7 at 5 sigma), will enable detections of (i) photospheric emission for more than 500 cluster members with B5 or earlier spectral types and (ii) robust detection of IR excess emission from several hundred debris disk candidates with spectral types earlier than K2-K4. In addition to providing improved constraints on the wavelength dependent evolution timescales of evolved circumstellar disks, these data will probe the terrestrial regions of solar-type stars at a time when we expect Earth-like planets to accumulate most of their mass and to produce copious amounts of debris . If terrestrial planet formation is relatively common in the Double Cluster, these data will yield unambiguous detections of the debris disk remnants of this process.

Spitzer Space Telescope - General Observer Proposal #50664

MIPS 24 micron observations of h & chi Persei: detecting the debris of terrestrial planet formation at 13 Myr

Principal Investigator: Scott Kenyon
Institution: Smithsonian Astrophysical Observatory

Technical Contact: Scott Kenyon, Harvard-SAO

Co-Investigators:
Thayne Currie, Smithsonian Astrophysical Observatory
Zoltan Balog, Steward Observatory
Benjamin Bromley, University of Utah

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 13.5

Abstract:
We propose to build on our successful observational study of the 13 Myr-old Double Cluster h & chi Persei. Using IRAC/MIPS data together with ground-based near-IR imaging and optical spectroscopy, we have (i) discovered 10 stars with clear evidence for terrestrial planet formation, roughly tripling the number of these sources currently known, (ii) developed the first evidence for a clear maximum at 10-20 Myr in the amount of dusty debris from planet formation in stars slightly more massive than the Sun, (iii) provided the first demonstration of a robust relation between the frequency of dust emission and the masses of stars forming planets at 10-15 Myr, and (iv) discovered roughly 25 cluster stars with clear evidence for gaseous circumstellar disks. Here, we request MIPS observations of the low density halo regions surrounding the clusters. Together with MIPS observations of the cluster cores and deep IRAC observations of the clusters and halo, these data will yield a map with a total area of 0.6 sq deg (900 sq pc). Our target MIPS sensitivity, 115 micro-Jy ([24] = 12.0 at 5 sigma), will enable detections of (i) photospheric emission for more than 500 10-20 Myr-old stars with B5 or earlier spectral types and (ii) robust detection of IR excess emission from several hundred debris disk candidates with spectral types F2--K2. In addition to providing improved constraints on the wavelength-dependent evolution timescales of evolved circumstellar disks, these data will probe the terrestrial regions of solar-type stars at a time when we expect Earth-like planets to accumulate most of their final mass. Given current estimates for the rate of terrestrial planet formation in the Double Cluster, these observations will yield unambiguous detections of the debris disk remnants of this process and will provide us with robust estimates for the frequency of terrestrial planet formation in the dense environment of the two clusters and the less dense environment of the halo.

Spitzer Space Telescope - Directors Discretionary Time Proposal #1098

Crystalline Silicates in Circumstellar Accretion Disks

Principal Investigator: Jacqueline Kessler-Silacci
Institution: University of Texas

Technical Contact: Jacqueline Kessler-Silacci, University of Texas

Science Category: circumstellar/debris disks
Observing Modes: MipsSed
Hours Approved: 10.0

Abstract:
This research program, which includes 10 hours of SIRTF observing time, is designed to study the effects of processing of ice and dust in proto-planetary systems. Spectroscopic observations with SIRTF's Infrared Spectrograph obtained from the "Cores to Disks" Legacy Science project will be combined with new SED observations from the Multiband Imaging Photometer for SIRTF to determine the major dust and ice components throughout the star formation process. The sensitivity of SIRTF will enable observations of silicates around a variety of solar-type post-main sequence stars and ices in very young stellar objects and in edge-on disks. These observations are SIRTF Fellow guaranteed time.

Spitzer Space Telescope - General Observer Proposal #30490

Completing the Census of Debris Disks around Nearby Stars

Principal Investigator: David Koerner
Institution: Northern Arizona University

Technical Contact: David Koerner, Northern Arizona University

Co-Investigators:
Zahed Wahhaj, Northern Arizona University
Angela Cotera, Seti Institute
David Trilling, University of Arizona
Karl Stapelfeldt, Jet Propulsion Laboratory
Deborah Padgett, Sirtf Science Center/Caltech
Sergio Fajardo-Acosta, Spitzer Science Center/Caltech
Dana Backman, Ames Research Center

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 105.0

Abstract:
We propose to complete a medium-scale MIPS 24 and 70 micron census of Sun-like stars in order to identify additional dust systems for detailed follow-up within the Spitzer mission lifetime. Our sample builds upon results from disparate GTO and GO programs to establish a truly volume-limited survey of K,G, and F dwarfs (0.7 msun < M* < 1.7 msun) within 25 pc. To achieve this goal, we add new observations of 660 objects to the current sample of 300 targets in the ROC for a combined volume-limited sample of 960 Sun-like stars. Assuming a 10% detection rate derived from other studies, we expect to discover 65 new disk systems. To provide a lasting resource to the community and for comparison with stellar properties likely to affect disk incidence, we will archive our results into the NStars Database (http://nstars.nau.edu) after publication together with appropriate GTO/GO data when these become publicly available.

Spitzer Space Telescope - General Observer Proposal #50538

A follow-up study of warm debris disks discovered in the Spitzer archive: investigation of the structure and origin of the closest analogues of the inner Solar System

Principal Investigator: Agnes Kospal
Institution: Konkoly Observatory

Technical Contact: Agnes Kospal, Konkoly Observatory

Co-Investigators:
Peter Abraham, Konkoly Observatory
Daniel Apai, Steward Observatory, University of Arizona
Carol A. Grady, NASA Goddard Space Flight Center
Thomas Henning, Max-Planck-Institut fur Astronomie
Csaba Kiss, Konkoly Observatory
Attila Moor, Konkoly Observatory
Ilaria Pascucci, Steward Observatory, University of Arizona

Science Category: circumstellar/debris disks
Observing Modes: IrsStare MipsPhot
Hours Approved: 25.9

Abstract:
Warm debris disks are thought to be the closest analogues of our inner Solar System. The number of known warm disks is very low, only a dozen of observed systems harbour such structures. The aim of our proposal is to identify and characterize a large number of new disks in a carefully selected sample of 30 warm disk candidates. The input sample of F, G, and K stars is the outcome of our extensive preparatory work on archival Spitzer data. We propose to use IRS and MIPS observations to confirm the existence of warm disk around each system, and characterize them in terms of disk structure and grain properties. On the basis of the new observations, we will comment on how frequent warm disks are around solar-type stars. This will provide information on the solid matter content in the most interesting inner regions of exosolar systems, where Earth-like planets might be currently forming. We will also give hints on the origin of dust in warm debris disks, by investigating whether the fractional luminosity of the system is compatible with the prediction of a steady state evolutionary model for that specific age. Systems inconsistent with this scenario might represent a rare transient event, like an asteroid belt collision or an analogue of the Late Heavy Bombardment (LHB). From our observations we may collect arguments for either of the two events, in particular by analysing the presence of far-infrared excess and mid-infrared spectral features. We may be able to comment on whether LHB-type events - which probably deplete the outer planetesimal belt as it happened in the Solar System - could occur in other systems, and whether they represent the rule or the exception. Since the main part of the program will be the IRS observations, only Spitzer could do the proposed study. The requested time is 25.9 hours.

Spitzer Space Telescope - General Observer Proposal #50152

Determining Inner-Disk Chemistry

Principal Investigator: Andrew Kruger
Institution: University of California, Davis

Technical Contact: Andrew Kruger, University of California, Davis

Co-Investigators:
Matt Richter, UC Davis
John Carr, NRL
Joan Najita, NOAO
Dan Jaffe, UT Austin
John Lacy, UT Austin
Greg Doppmann, NOAO

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 3.7

Abstract:
Observational data regarding gas phase properties, such as temperature and chemical abundances, in the inner few AU around young stars are are woefully sparse. Past Spitzer IRS observations of IRS 46 suggest that molecular absorption provides a method for examining this region and possibly sampling the disk itself (Lahuis et al. 2006). We propose to observe targets with large line-of-sight extinction, edge-on disks and the class of objects known as infrared companions to search for gas phase absorption in molecules such as C2H2, HCN, and CO2. In addition, we will use the SL1 and SL2 modules to extend the search to include the two molecules predicted to be most abundant in the inner disk, H2O and CH4. The combined data sets will provide abundances of many of the molecules considered important to inner disk chemistry and help us to examine the chemical evolution of protoplanetary disk gas relative to the interstellar medium and our own solar system.

Spitzer Space Telescope - General Observer Proposal #20124

Revisiting NGC 2547: A Search for a More Complete Census of Debris Disks at 25 Myr

Principal Investigator: Charles Lada
Institution: Harvard-Smithsonian Center for Astrophysics

Technical Contact: Charles Lada, Harvard-CfA

Co-Investigators:
Paula Teixeira, Harvard-CfA
Erick Young, U. Arizona

Science Category: circumstellar/debris disks
Observing Modes: MipsScan
Hours Approved: 29.7

Abstract:
Spitzer observations of the 25 Myr old stellar cluster NGC 2547 has provided us with an initial census of the disk population in the cluster. Of the candidate member sources, selected using optical and near-infrared ground-based photometry, only 5% show some excess emission in the IRAC bands suggestive of the presence of primordial or protoplanetary disks, although no excess emission is detected at near-infrared wavelengths for these sources. These objects are late type (SpT > K) and the lowest mass members of the cluster. The MIPS observations (specifically 24um band) have detected photospheres of all the A-type stars in the cluster and we have determined that 20% of these have excess emission at 24um. Thus by 25 Myr a significant number of debris disks have developed around A-type stars. Debris disk fractions are highly desirable in order to investigate planet formation around later-type stars but cannot be determined unless we obtain deeper observations at 24um. In order to aquire a better census of debris disks for cluster members of lower mass and later spectral type we propose to obtain deeper MIPS observations of NGC 2547.

Spitzer Space Telescope - General Observer Proposal #40113

YSO inner disk chemistry - pushing the IRS limits

Principal Investigator: Fred Lahuis
Institution: Leiden Observatory, SRON Groningen

Technical Contact: Fred Lahuis, Leiden Observatory, SRON Groningen

Co-Investigators:
Geoffrey Blake, Division of GPS, Caltech
Adwin Boogert, NOAO Gemini Science Center
Cornelis Dullemond, MPIA Heidelberg
Neal Evans, University of Texas
Michiel Hogerheijde, Leiden Observatory
Klaus Pontoppidan, Division of GPS, Caltech
Ewine van Dishoeck, Leiden Observatory

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 19.9

Abstract:
The aim of this proposal is to observe molecular absorption bands at 13-15 micron of gaseous acetylene (C2H2), hydrogen cyanide (HCN), and carbon dioxide (CO2) in the planet-forming zones of a sample of nearly edge-on disk sources. These molecules are predicted to be among the most abundant organic molecules in hot gas and the precursors of much more complex, prebiotic species. In addition to being unique probes of inner disk chemistry, the molecular bands also provide a direct measure of the temperature and density of the warm gas in the planet-forming zones of disks. The presence of warm C2H2, HCN, and CO2 gas has already been reported in two proto-planetary disks. However, in existing IRS observations of other disks, the bands of these molecules are expected to lie just below the detection limit allowed by the achieved dynamic range. We have designed a new observing strategy designed to push the achievable dynamic range of the SH module by at least a factor of 3-5 to conduct the most sensitive search possible in sixteen disks. The targets have been selected on basis of deep absorption at 4.7 micron due to warm CO gas in the inner disk. The data will most certainly be the driving force for further development of optimal extraction algorithms (developed as part of the c2d legacy program) to obtain the highest S/N spectra of which the IRS is capable.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #100

MIPS Survey of eta Cha cluster

Principal Investigator: Charles Lawrence
Institution: JPL

Technical Contact: Nick Gautier, JPL

Science Category: circumstellar/debris disks
Observing Modes: MipsScan
Hours Approved: 2.6

Abstract:
The eta Cha cluster will be mapped to high sensitivity with MIPS scan map to search for circumstellar disks around the bright cluster stars and to search for cluster brown dwarfs. The mapped area is approximately 0.5 deg x 0.5 deg centered approximately on eta Cha itself

Spitzer Space Telescope - General Observer Proposal #3508

From protoplanetary disks to debris disks: The evolution of circumstellar disks in the 9 Myr old eta Chamaeleontis cluster

Principal Investigator: Warrick Lawson
Institution: University of New South Wales

Technical Contact: Warrick Lawson, University of New South Wales

Co-Investigators:
Eric D. Feigelson, Penn State University
L.B.F.M. Waters, University of Amsterdam
C. Dominik, University of Amsterdam
Th. Henning, MPIA, Heidelberg, Germany
A.G.G.M. Tielens, Kaptein institute, University of Groningen
Jeroen Bouwman, MPIA, Heidelberg, Germany

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 5.8

Abstract:
We propose a study of protoplanetary disks around an unique sample of newly discovered pre-main-sequence stars in the relatively evolved nearby cluster eta Chamaeleontis. The eta Cha cluster provides us with the singular opportunity to study the influence of stellar properties on the evolutionary time-scales of protoplanetary disks. It consists of a well characterized, complete and unbiased sample of coeval T Tauri and Vega type stars at an age of 9 Myr. At this age a (proto)planetary system might have formed and the transition between 'gas-rich' proto-planetary to 'gas-poor' debris disks will occur. By studying the chemical processing and evolution of the circumstellar dust grains, the building blocks of planets, present in these disks, important insights into the formation mechanism and disk evolution can be obtained. An important tool for this purpose is infrared spectroscopy at mid and far infrared wavelengths, where many dust species such as silicates emit thermal radiation, resulting in clear spectral signatures. The shape and strength of these spectroscopic features reveal clues about the size distribution, solid state (amorphous/crystalline) and composition of the emitting dust grains, which are valuable tracers for the dust processing history. As a result of the coeval nature of the cluster, differences in dust properties cannot be caused by age, but rather by other stellar properties such as luminosity and mass or binarity, or different initial masses of the disks. The ultimate goal is to understand the processes governing the composition and geometry of the dust in protoplanetary disks, evolving into a dust composition observed in solar system comets, by comparing Spitzer-IRS spectra of the eta Cha cluster members. These spectra can provide a crucial contribution to existing programs by providing the link between the evolution of low- and intermediate-mass pre-main-sequence stars.

Spitzer Space Telescope - General Observer Proposal #50330

First Debris Disk with Hot Dust Around a Nearby M-dwarf

Principal Investigator: Jean-Francois Lestrade
Institution: Observatoire de Paris-Meudon

Technical Contact: Jean-Francois Lestrade, Observatoire de Paris-Meudon

Co-Investigators:
Charles Beichman, JPL/MSC
Geoff Bryden, JPL/MSC
Carey Lisse, Johns Hopkins Univ./APL
Peter Plavchan, Caltech/IPAC
Mark C. Wyatt, Inst. of Astron., Cambridge, UK

Science Category: circumstellar/debris disks
Observing Modes: IrsStare MipsPhot
Hours Approved: 1.1

Abstract:
From IRAS data, we present strong evidence for a large infrared excess above the expected photospheric flux at 12 and 25 microns for the 21.8 pc M1.5 dwarf GJ 730. This excess is caused by emitting dust with temperature of T~400 K, located very close to the star at ~0.1 AU. This hot dust is most likely associated with the destruction of planetesimals in an asteroid belt, or with dust released in the sublimation of a swarm of comets, or of one large supercomet, and would be unique. Hot dust has been found only around a few Sun-like stars (FGK) but never around a field M-dwarf. We propose to verify and study this excess with MIPS 24 microns and IRS 5-35 microns observations. This will allow a search to look for IR silicate spectral features that GJ730 is expected to have, and allow us to distinguish between the different possible interpretations (cometary/asteroidal) of the hot dust. In addition, confirming this excess, as the only reliable IRAS excess in the large sample of 280 IRAS M-dwarfs we have studied, will provide a robust determination of the frequency of warm debris disks around M-dwarfs for the first time (0.4% for our 280 star sample).

Spitzer Space Telescope - General Observer Proposal #50356

Debris Disks around the Nearest Young M Dwarfs

Principal Investigator: Michael Liu
Institution: University of Hawaii

Technical Contact: Michael Liu, University of Hawaii

Co-Investigators:
Evgenya Shkolnik, IfA/Hawaii
I. Neill Reid, STScI
Zahed Wahhaj, IfA/Hawaii

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 16.3

Abstract:
We propose to search for debris disks around carefully selected sample of 95 young (<~500 Myr), nearby (d<25 pc) M dwarfs using Spitzer/MIPS. M dwarfs are the most common type of stars and thus could represent the most common hosts of planetary systems. Little is known about debris disks around M dwarfs, as very few examples are known. Our proposed Spizer observations of low-mass stars will have sufficient sensitivity for meaningful comparison with higher mass stars. This well-constructed sample consists of the youngest members of the immediate solar neighborhood, ideal to identify debris disks around low-mass stars, to robustly determine their frequency, and to study their physical properties during a key epoch of planet formation. Also, newly discovered disks will be among the closest ones to Earth and highest fractional luminosity, making them prime targets for multi-wavelength and high angular resolution follow-up by future ground and space-based capabilities.

Spitzer Space Telescope - Theoretical Research Proposal #30197

Modeling the PAH Emission Spectra of Protoplanetary and Debris Disks

Principal Investigator: Aigen Li
Institution: University of Missouri-Columbia

Technical Contact: Aigen Li, University of Missouri-Columbia

Co-Investigators:
J.I. Lunine, University of Arizona

Science Category: circumstellar/debris disks
Dollars Approved: 82239.0

Abstract:
The 3.3, 6.2, 7.7, 8.6 and 11.3 micron emission features of polycyclic aromatic hydrocarbon (PAH) molecules have been detected in protoplanetary disks around Herbig Ae/Be stars and T Tauri stars and in debris disks around main-sequence stars. PAHs play an important role in the thermal budget and chemistry of the gas in the disk, by providing photoelectrons for heating the gas and large surface areas for chemical reactions. Stochastically heated by a single UV/visible photon, the PAH emission is spatially more extended than large grains and therefore, the disks can be more easily resolved at the PAH emission bands. We propose to model the PAH emission spectra of protoplanetary and debris disks obtained by Spitzer and ISO. We will first calculate the temperature probability distribution functions dP/dT for both neutral and ionized PAHs of a wide range of sizes, at a wide range of radial distances (from the central star) in disks illuminated by stars of a wide range of spectral types. By modeling the PAH emission of dust disks, we will be able (1) to derive the abundance, size and spatial distributions of PAHs; (2) to derive the PAH photoelectric heating rates which dominate the gas heating in the disk surface layers; and (3) to see how the abundance and properties of the PAHs vary among disks at different evolutionary stages and illuminated by stars of different parameters (e.g. luminosity, spectral type). This program will create a web-based ‘‘library’’ of the temperature distribution functions dP/dT of PAHs (and their emission spectra and photoelectric heating rates) as a function of size, charge state, and radial distance in disks illuminated by stars of different spectral types. This library, a useful tool for interpreting the PAH emission features of dust disks obtained by Spitzer and for understanding the disk chemistry, will be made publicly available by April 2007 via the WWW at http://www.missouri.edu/~lia/.

Spitzer Space Telescope - General Observer Proposal #3557

Embedded Protostars: Looking for Holes in Star Formation

Principal Investigator: Leslie Looney
Institution: Univ of Illinois at Urbana-Champaign

Technical Contact: Leslie Looney, Univ of Illinois at Urbana-Champaign

Co-Investigators:
Lee Mundy, Univ of Maryland
Nikolaus Volgenau, Univ of Maryland
Murad Hamidouche, Univ of Illinois at Urbana-Champaign
Woojin Kwon, Univ of Illinois at Urbana-Champaign
Shiya Wang, Univ of Illinois at Urbana-Champaign

Science Category: circumstellar/debris disks
Observing Modes: IracMap MipsPhot
Hours Approved: 3.5

Abstract:
The structure of the circumstellar envelope of young stellar objects has important ramifications on protostellar evolution,multiplicity, and the formation of the circumstellar disk and eventually planets. Even though these regions are very highly extincted, the Spitzer Space Telescope can peer into these protostellar envelopes and unlock their secrets. We are proposing very deep, single pointing observations of 5 Class 0 sources (4 pointings) in the 4 bands of IRAC (900 seconds) and the 24 micron band of MIPS (600 seconds maps). The sources were selected from our BIMA millimeter array interferometric survey of deeply embedded Class 0 sources. Our current models of the circumstellar envelope density profile have produced surprising results: the density is steeper than theoretically predicted. However it can be argued that the model is oversimplified due to a lack of an outflow cavity constraint. This proposal has two main goals: (1) to look for the holes of star formation toward these embedded systems where the scattered light from the star peeks through the highly extincted cloud region, and (2) to examine the multiplicity of the region by searching for heretofore undiscovered brown dwarves or other low mass companions.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #72

A Search for Terrestrial Planetary Debris Systems and Other Planetary Debris Disks

Principal Investigator: Frank Low
Institution: University of Arizona

Technical Contact: Paul Smith, University of Arizona

Science Category: circumstellar/debris disks
Observing Modes: IracMap IrsStare MipsPhot MipsSed
Hours Approved: 48.6

Abstract:
MIPS photometry will be obtained for a large sample of young, relatively nearby (generally within 100 pc) stars. The primary objectives of this program are: 1) identify systems possessing warm dust emission analogous to the zodiacal bands of the inner solar system, 2) find further examples of the pre-main-sequence planetary debris system (PDS) discovered for HD 98800B, and 3) identify Vega-type cooler dust excesses early in the evolution of their illuminating stars. This survey will constrain models of the origin and evolution of PDSs with the ultimate goal of determining how often, and in what circumstances terrestrial planets are formed. In addition, the survey will identify objects having mid-IR excesses that will be suitable targets for follow-up ground- and space-based observations at higher resolution. This program is a collaboration among four SIRTF GTOs (F. Low, M. Werner, M. Jura, and R. Gehrz). Each GTO will will submit his portion of the observational program separately.

Spitzer Space Telescope - General Observer Proposal #40134

An IRS Survey of Disks around Stars and Brown Dwarfs in Lupus

Principal Investigator: Kevin Luhman
Institution: Pennsylvania State University

Technical Contact: Kevin Luhman, Pennsylvania State University

Co-Investigators:
Dan Watson, University of Rochester
Nuria Calvet, University of Michigan
Paola D'Alessio, UNAM
Lee Hartmann, University of Michigan
Bill Forrest, University of Rochester
Peter Allen, Pennsylvania State University

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 17.8

Abstract:
We have recently completed an IRAC and MIPS survey of one of the nearest star-forming clusters to the Sun, cloud 3 in Lupus (1 Myr, 140-200 pc). Using these photometric measurements, we have identified the stellar and substellar members of the cluster that harbor circumstellar disks. We now propose to perform an IRS spectroscopic survey of these disks to study the structure and composition of circumstellar disks across a wide range of masses (2 to 0.02 M_sun) and to search for evidence of ongoing planet formation via the detection of inner disk holes.

Spitzer Space Telescope - General Observer Proposal #40357

Search for Terrestrial Temperature Debris Around Needles in the Haystack: A Survey for Disks in a Newly Discovered Nearby 20-30 Myr Old Association

Principal Investigator: Eric Mamajek
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Eric Mamajek, Smithsonian Astrophysical Observatory

Co-Investigators:
Serena Kim, University of Arizona
Michael R. Meyer, University of Arizona

Science Category: circumstellar/debris disks
Observing Modes: IracMap MipsPhot
Hours Approved: 29.9

Abstract:
We propose to conduct the first survey for circumstellar disks in a newly identified young association using IRAC and MIPS. With an age of 25 Myr and a distance of 95 pc, the "32 Ori Group" is the first northern, nearby young association (<100 Myr, <100 pc) to be discovered. Despite being a relatively small sample, this group is an important Spitzer target due to its age (nearby stellar groups with ages of 15-50 Myr are rare) and proximity (allowing Spitzer to efficiently detect smaller amounts of dust for shorter exposure times for low-mass pre-main sequence stars). If our own solar system is representative, then one expects that these systems might be in an evolutionary stage where terrestrial planet formation is an advanced state, but considerable amounts of dust might be continually replenished (and detectable with Spitzer) from the gravitational stirring of small planetesimals by the largest protoplanets. We will survey these newly available novel targets with the IRAC and MIPS instruments to identify targets with IR excess. Model fits to spectral energy distributions will constrain the dust content in these disks and enable comparison of data to models at this important age range when the terrestrial planets of our own solar system were being assembled.

Spitzer Space Telescope - General Observer Proposal #3441

An IRAC view of the eclipsing pre-main-sequence star KH 15D

Principal Investigator: Massimo Marengo
Institution: Harvard-Smithsonian Center for Astrophysics

Technical Contact: Massimo Marengo, Harvard-CfA

Co-Investigators:
Josh Winn, Harvard-Smithsonian Center for Astrophysics
Tom Megeath, Harvard-Smithsonian Center for Astrophysics
Charles Lada, Harvard-Smithsonian Center for Astrophysics
Eric Young, Steward Observatory, University of Arizona
Lee Hartmann, Harvard-Smithsonian Center for Astrophysics
John Stauffer, IPAC, California Institute of Technology
Dimitar Sasselov, Harvard-Smithsonian Center for Astrophysics

Science Category: circumstellar/debris disks
Observing Modes: IracMap
Hours Approved: 1.4

Abstract:
We propose to determine the cause of the mysterious eclipses of the T Tauri star KH 15D, located in the young (2-4 Myr) cluster NGC 2264. A new and promising theory holds that the system is a pre-main-sequence binary being occulted by the edge of an inclined circumbinary disk. We will test this theory with Spitzer, by searching for infrared emission from the disk, and measuring the eclipse depth as a function of infrared wavelength. If the theory is correct, this binary will be valuable as a test of pre-main- sequence stellar models (because the masses and radii of its components can be measured), and as a fascinating challenge in circumstellar disk dynamics (because the sharpness and inclination of the disk require explanation).

Spitzer Space Telescope - Archive Research Proposal #20739

Investigating T Tauri Disk Evolution

Principal Investigator: Caer-Eve McCabe
Institution: JPL/Caltech

Technical Contact: Caer-Eve McCabe, JPL/Caltech

Co-Investigators:
Gaspard Duchene, Observatoire de Grenoble
Cathy Clarke, Cambridge University
Russel White, Caltech

Science Category: circumstellar/debris disks
Dollars Approved: 58500.0

Abstract:
We propose to use Spitzer archival IRAC observations of a sample of 119 T Tauri stars with M2-M9 spectral types in the ~2 Myr old star forming regions of Taurus and IC 348, in order to investigate whether the timescale of disk evolution is dependent on the stellar mass. Comparing the near- and mid-infrared excesses due to dust emission from the inner few AU of the circumstellar disks around these young, low mass stars, we will search for the presence of inner disk holes, one of the key signatures of viscous disk evolution or disk evolution via photoevaporation and compare the disk diagnostics with the known accretion diagnostics. This proposed sample of T Tauri stars provides a complimentary sample in terms of spectral type to the results from our recent ground-based mid-infrared survey of disks and to the Cores to Disks WTTS program, and will investigate the fraction of systems with inner disk holes as a function of mass.

Spitzer Space Telescope - General Observer Proposal #30843

IRS and MIPS observations of transitional disks with inner holes

Principal Investigator: Bruno Merin
Institution: Leiden Observatory

Technical Contact: Joanna Brown, CalTech

Co-Investigators:
Joanna Brown, CalTech
Klaus Pontoppidan, CalTech
Geoffrey Blake, CalTech
Vincent G. Geers, Leiden Observatory
Jean-Charles Augereau, University of Grenoble
Lucas Cieza, Texas University
Ewine F. van Dishoeck, Leiden Observatory
Cornelius Dullemond, Max Plank Institute fur Astrophysik
Jackie Kessler-Silacci, Texas University
Neal Evans, Texas University
Peggy Varniere, University of Grenoble

Science Category: circumstellar/debris disks
Observing Modes: IrsStare MipsPhot
Hours Approved: 22.7

Abstract:
We propose to observe with IRS and MIPS2 at 70 microns a sample of 26 new young stars with inner holes in their disks, discovered as part of the c2d Spitzer Legacy Program. The sample is five times larger than the very small number of previously known transitional disks. The few objects of this kind that have been found to date led to the belief that they represent a very short-lived evolutionary phase of the young star+disk system. Thus, they may serve as pivotal links to the optically thick disk/Classical T Tauri star phase on the one hand and Weak-lined T Tauri stars or debris disks on the other. The objects were selected from the c2d mapping data of five nearby star-forming clouds thanks to their characteristic Spectral Energy Distribution, which shows no flux excess in the near- or mid-infrared range and a large excess at wavelengths longer than 10 microns. They are specially interesting because they have optically thick disks beyond a few AU but large inner holes where planets could be forming, and thus may provide a crucial window into the processes of Jovian planet assembly and disk dissipation. The IRS spectroscopy will be used to study the dust composition and evolutionary state of the disks and to characterize in detail the geometry of the inner holes. The MIPS2 imaging at 70 microns will be used, together with optical, 2MASS, IRAC,and MIPS1 fluxes to determine the physical and chemical structure of the outer disks. Sophisticated radiative transfer and dynamical disk models will be used to interpret the observations. The team, mostly c2d members, will apply its broad experience in IRS analysis and self-consistent SED fitting. We have complementary optical observations in hand and thus have a very well characterized sample.

Spitzer Space Telescope - Legacy General Observer Proposal #148

The Formation and Evolution of Planetary Systems: Placing Our Solar System in Context

Principal Investigator: Michael R. Meyer
Institution: The University of Arizona

Technical Contact: Michael R. Meyer, The University of Arizona

Co-Investigators:
Dana Backman, Franklin and Marschall College
Steven V.W. Beckwith, Space Telescope Science Institute
John M. Carpenter, California Institute of Technology
Martin Cohen, University of California-Berkeley
Thomas Henning, Astronomisches Institute, Jena
Lynne A. Hillenbrand, California Institute of Technology
Dean Hines, The University of Arizona
David J. Hollenbach, NASA-Ames Research Center
Jonathan Lunine, The University of Arizona
Renu Malhotra, The University of Arizona
Joan Najita, National Optical Astronomy Observatories
Deborah L. Padgett, California Institute of Technology
David R. Soderblom, Space Telescope Science Institute
John R. Stauffer, California Institute of Technology
Stephen E. Strom, National Optical Astronomy Observatories
Daniel M. Watson, University of Rochester
Stuart J. Weidenschilling, Planetary Science Institute
Erick Young, The University of Arizona

Science Category: circumstellar/debris disks
Observing Modes: IracMap IrsStare MipsPhot
Hours Approved: 350.0

Abstract:
We propose to trace the evolution of planetary systems at all ages ranging from: (1) 3-10 Myr when stellar accretion from the disk terminates; to (2) 10-100 Myr when planets achieve their final masses via coalescence of solids and accretion of remnant molecular gas; to (3) 100-1000 Myr when the final architecture of solar systems takes form and frequent collisions between remnant planetesimals produce copious quantities of dust; and finally to (4) mature sys tems of age comparable to the Sun in which planet-driven activity of planetesimals continues to generate detectable dust. Our strategy is to use carefully calibrated spectral energy distributions and high-resolution spectra to infer the radial distribution of dust and the molecular hydrogen content of disks surrounding a sample of 700 solar-like stars distributed uniformly in log-age over 3 Myr to 10 Gyr. The high precision and fine sampling of SIRTF spectral energy distributions can reveal both the existence of planets and their approximate masses and radial distributions through modeling of the dynamical effects of planets in sculpting planetesimal distributions and orchestrating their collision frequency. The size of our target list is designed to provide robust sampling of what we expect based on the dramatic exo-solar planet discoveries of the past half decade to be a wide diversity of planetary system architectures. We plan to deepen our appreciation of the range of possible outcomes of the planet formation process -- thus placing our own solar system in context. Our proposed Legacy program promises to provide: (1) new insight into problems of fundamental scientific and philosophical interest; (2) calibration with precision 2-3 times that of standard SIRTF data products, to the benefit of all SIRTF observers; (3) new numerical tools for simulating the dynamical history of forming solar systems; and (4) a rich database to stimulate follow-up observations with SIRTF, with existing and future ground-based facilities, and later with SI

Spitzer Space Telescope - General Observer Proposal #40303

Dust Formation near Hot Non-Supergiant Stars

Principal Investigator: Anatoly Miroshnichenko
Institution: University of North Carolina, Greensboro

Technical Contact: Anatoly Miroshnichenko, U. North Carolina, Greensboro

Co-Investigators:
Karen Bjorkman, University of Toledo
Richard Gray, Apallachian State University
Richard Rudy, The Aerospace Corporation
David Lynch, The Aerospace Corporation
Alex Carciofi, University of Sao Paulo
Alexander Men'shchikov, CEA/Saclay Seevice d'Astrophysique

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 10.1

Abstract:
The formation of dust in circumstellar environments, and its dispersal into space is an essential step in the formation of planets and ultimately life. For many years, it was believed dust was created only around cool stars, but now we know hot massive stars, such as Wolf-Rayet stars are important in dust formation. We have discovered a third source - the environments of hot non-supergiant stars, whose spectra are characterized by strong emission lines and infrared excesses. This new group, the B[e] stars with warm dust, (B[e]WD), is the only group of dusty stars not yet observed by Spitzer. We propose to observe 25 B[e]WD objects with IRS to discover the properties of their circumstellar dust. Investigating these objects will help us to evaluate the importance of hot stars in the total picture of dust formation in our Galaxy and improve our understanding of mass-loss and dust formation in a wide range of environments around hot stars.

Spitzer Space Telescope - Archive Research Proposal #40799

The Effects of Stellar Metallicity on the Frequency of Debris Disks in Young Star Clusters

Principal Investigator: TalaWanda Monroe
Institution: Indiana University

Technical Contact: TalaWanda Monroe, Indiana University

Co-Investigators:
Catherine Pilachowski, Indiana University

Science Category: circumstellar/debris disks
Dollars Approved: 59617.0

Abstract:
Many surveys undertaken with Spitzer Space Telescope have used open clusters of disparate ages to study the frequency of debris disks as a function of stellar age. Parameters other than age that may influence planetary system formation and evolution should now be considered. The purpose of this investigation is to use archival MIPS observations of young open clusters to systematically investigate the role that stellar metallicity plays in the frequency of debris disks around late B through early F stars with age. This will be accomplished by using GTO and Legacy observations of 18 clusters within the age range of 3 to 200 Myr.

Spitzer Space Telescope - Archive Research Proposal #40412

Study of solar-type stars with planets, planetesimals and dust

Principal Investigator: Amaya Moro-Martin
Institution: Princeton University

Technical Contact: Amaya Moro-Martin, Princeton University

Co-Investigators:
Sebastian Wolf, Max Plank Institute for Astronomy in Heidelberg
Thomas Henning, Max Plank Institute for Astronomy in Heidelberg

Science Category: circumstellar/debris disks
Dollars Approved: 40000.0

Abstract:
We propose to estimate the location of the dust and the parent planetesimals in six of the nine planetary systems known to date to harbor both giant planets and debris disks. These six stars show excess emission at 70 micron but not at 24 microns, implying the presence of an inner region depleted of warm dust, with the bulk of the emission arising from cool material (T<100K) located mainly beyond 10 AU. This means that these stars not only harbor planets but also harbor an outer belt of dust-producing planetesimals and in this regard they resemble the Solar Sytem in its Jovian planets + Kuiper Belt configuration. Detailed SED and dynamical analysis of these systems has not yet been published. The results of this study will increase our understanding of the diversity of planetary systems, and will help us place our Solar System into context.

Spitzer Space Telescope - General Observer Proposal #40372

Mid-infrared variability as a probe of protoplanetary disk structure

Principal Investigator: James Muzerolle
Institution: Steward Observatory, U. Arizona

Technical Contact: James Muzerolle, Steward Observatory, U. Arizona

Co-Investigators:
Lori Allen, CfA
Zoltan Balog, Steward Observatory
Nuria Calvet, University of Michigan
Paola D'Alessio, Instituto de Astronomia UNAM
Elise Furlan, UCLA/NAI
S. Thomas Megeath, University of Toledo
August Muench, Harvard-Smithsonian Center for Astrophysics
George Rieke, Steward Observatory
William Sherry, NOAO

Science Category: circumstellar/debris disks
Observing Modes: IrsStare MipsScan
Hours Approved: 22.5

Abstract:
We propose to obtain multi-epoch MIPS and IRS observations of the young stellar cluster IC 348 in order to study in detail the mid-infrared variability of circumstellar disks. Preliminary results based on just the two existing epochs of imaging data indicate a surprising degree of variability from 3.6-24 microns, with nearly half of all known cluster members with disks exhibiting variable emission by up to half a magnitude. Interestingly, some of the strongest variables are stars with significantly evolved disks, including transition objects with optically thin inner holes. By constraining the variability timescales with high-cadence MIPS 24 micron imaging and the spectral shape of the flux changes with IRS 5-37 micron spectra, we will be able to isolate and characterize the source(s) of the mid-IR variability. These data will provide a valuable tool for understanding disk structure, particularly in the case of evolved disks whose structure may be highly modified by ongoing planet formation.

Spitzer Space Telescope - General Observer Proposal #30300

Warm Gas in Transitional Disks

Principal Investigator: Joan Najita
Institution: NOAO

Technical Contact: Joan Najita, NOAO

Co-Investigators:
Stephen Strom, NOAO
John Carr, NRL
David Hollenbach, NASA/Ames
Uma Gorti, UC Berkeley
Ilaria Pascucci, Steward Observatory
Luke Keller, Ithaca College
Dan Watson, U. Rochester

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 39.0

Abstract:
Studying gas in the planet formation region of disks is a potentially powerful tool with which to identify systems in various states of planet formation. Planet formation theory predicts that evolutionary states from planetesimal formation to early- and late-stages of giant planet formation will have distinct characteristics with regard to their gas distribution within 10 AU and their stellar accretion rates. Transitional disks are exciting environments in which to search for evidence of planet formation since their SEDs indicate that significant evolution has occured. We therefore propose use Spitzer to assess the presence and filling factor of gas in the region within 10 AU of transitional disks and thereby probe empirically the evolutionary state of these systems. Spectral line diagnostics accessible with Spitzer are ideal for probing gas in the 1-10 AU region of the disk. We will supplement these observations with ground-based observations that probe stellar accretion rates and the gas within 1 AU of the star.

Spitzer Space Telescope - General Observer Proposal #40338

[NeII]: A Powerful New Probe of Dissipating Disks

Principal Investigator: Joan Najita
Institution: National Optical Astronomy Observatory (NOAO)

Technical Contact: John Carr, Naval Research Laboratory

Co-Investigators:
John Carr, NRL
Elise Furlan, UCLA/NAI
Rowin Meijerink, UC Berkeley
Al Glassgold, UC Berkeley
Ilaria Pascucci, Steward Observatory
David Hollenbach, NASA/Ames
Uma Gorti, UC Berkeley

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 29.2

Abstract:
The gas dissipation timescale of circumstellar disks provides a direct constraint on the time available for giant planet formation. As a result, measuring the lifetime of gas in the planet formation region of the disk (< 20 AU) can distinguish between core accretion and gravitational instability as the dominant pathway for giant planet formation. We therefore propose to use Spitzer IRS to probe the lifetime of gaseous disks using the [NeII] emission line. Both recent theoretical predictions and recent Spitzer spectroscopy indicate that the [NeII] line is a robust tracer of small gas column densities in the region within 20 AU and, therefore, an excellent probe of dissipating gaseous disks over the range of radii relevant to giant planet formation. The proposed measurements will allow us to place stringent constraints on the presence or absence of residual disk gas at the level of 10^(-5)-10^(-6) solar masses.

Spitzer Space Telescope - General Observer Proposal #30381

Mid-IR spectroscopy of pre-main-sequence stars in the sigma Orionis cluster

Principal Investigator: Joana Oliveira
Institution: Keele University

Technical Contact: Joana Oliveira, Keele University

Co-Investigators:
Jacco van Loon, Keele University
Mario van den Ancker, European Southern Observatory
Jeroen Bouwman, MPIA Heidelberg
Rob Jeffries, Keele University

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 14.3

Abstract:
Even though we do not yet fully understand the formula for planet formation, we know where to find the ingredients: in circumstellar disks around young low-mass stars. It is now believed that most solar mass stars form in OB associations. We propose to perform IRS spectroscopy of a sample of classical T Tauri stars (CTTS, pre-main-sequence stars with disks) in the 3-5 Myr-old Sigma Orionis OB association. Pre-main-sequence objects have been identified in this region down to substellar masses. Our previous ground-based observations unveiled a rich variety of intriguing objects (e.g. "old" jet and "proplyd" sources) some of them with unusual mineralogy (a tentative identification of self-absorbed forsterite in IRAS 05358-0238) providing a tantalizing hint that the environment can play a strong role in the disks' mineralogy evolution. Our Spitzer IRS sample includes the brightest cluster members that have been found to possess disks (mass range 0.4-1.5 solar masses), 4 irradiated jet sources and 1 proplyd-candidate source. In their spectra, we will identify bands due to amorphous and crystalline silicates and we will model the spectra to determine to what extent crystallisation and coagulation has taken place, and correlate this with stellar mass. We will investigate whether molecular hydrogen (and other gas-phase) emission lines and PAH emission band are present in the spectra of the irradiated jets and proplyd-candidate sources, to probe the extreme environments surrounding these objects. Our proposed observations will allow us to understand the nature and evolutionary status of these unusual objects. By comparison with observations of more quiescent environments that are part of Legacy programs, we will assess the disruptive influence of the massive O-star sigma Orionis. This will shed light on the processes that take place in the most abundant breeding grounds for planets and our Solar system.

Spitzer Space Telescope - General Observer Proposal #20382

Spitzer Spectroscopy of Young Stellar Disks in Lynds 1228

Principal Investigator: Deborah Padgett
Institution: California Institute of Technology

Technical Contact: Deborah Padgett, California Institute of Technology

Co-Investigators:
Pat Morris, Caltech
Manuel Guedel, University of Zurich
Luisa Rebull, Caltech
Jennifer Karr, Caltech
Sebastian Wolf, MPIA-Heidelberg
Alberto Noriega-Crespo, Caltech
Sergio Fajardo-Acosta, Caltech
Karl Stapelfeldt, Jet Propulsion Laboratory
Susan Stolovy, Caltech
Tim Brooke, Caltech
Sean Carey, Caltech
Misato Fukagawa, University of Tokyo

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 10.3

Abstract:
Using the MIPS and IRAC instruments on the Spitzer Space Telescope, we have investigated two aggregates of 14 bright young stellar objects in the Lynds 1228 cloud in Cepheus. The spectral energy distributions (SEDs) encompass both infrared (IR) Class II and Class III types, and at least one object has no excess at wavelengths shorter than 24 microns. The SEDs of these sources illustrate that there can be a diversity of disk evolutionary states within coeval stellar aggregates. We propose to further characterize these young stellar disks using the Spitzer Space Telescope Infra-Red Spectrograph (IRS). With these observations, we will obtain detailed knowledge of SED gaps, look for evidence of crystalline silicates indicating disk thermal evolution, and use atomic and molecular lines to evaluate shocked and quiescent gas in these systems.

Spitzer Space Telescope - Directors Discretionary Time Proposal #243

Remnant Gas in Debris Disk Systems: Confirmation of the Remarkable [FeI] Line Emission in HD 216803

Principal Investigator: Ilaria Pascucci
Institution: University of Arizona

Technical Contact: Michael R. Meyer, The University of Arizona

Co-Investigators:
Dave Hollenbach, NASA Ames Research Center
U. Gorti, NASA Ames Research Center
Serena Kim, Univ. of Arizona
Murray Silverstone, Univ. of Arizona
Pat Morris, NASA Herschel Science Center
J. Najita, National Optical Astronomy Observatory
Debbie Padgett, SSC
Dan Watson, University of Rochester

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 1.0

Abstract:
We propose to use 1 hour of Spitzer Director's Discretionary Time to perform follow-up high-resolution spectroscopy of the nearby main-sequence star HD 216803 and its disk. HD 216803 was observed as part of our 10 FEPS first-look sources to characterize the dissipation timescale in disks around solar-type stars. From a detailed analysis of its high-resolution Spitzer spectrum, we tentatively discovered [FeI] emission at 24 micron. Here, we propose to obtain more sensitive exposures with the LH module of the IRS to confirm this probable detection. The detection, if confirmed by the proposed DDT observations, will provide the first strong evidence for the existence of gas in the disk surrounding a main-sequence star at an age of about 100 Myr. This finding will have strong implications on planet formation models, favoring the core accretion over the gravitational instability scenario, and provides us with a powerful new tool for detecting gas in circumstellar disks. Thus, confirmation of this result is urgently needed. Because of the interest in these observations from the broader scientific community and of the implications that such a finding will have on the analysis of current data and planning of future GO proposals, we believe that the observations cannot be deferred until the next GO cycle. Therefore we ask for Director's Discretionary Time to re-observe our target in May. If these observations were delayed to Cycle 3, general observers would not have access to the results before Cycle 4, about two years from now.

Spitzer Space Telescope - Archive Research Proposal #30239

Stellar Companions as a Trigger for Rapid Dust Evolution

Principal Investigator: Ilaria Pascucci
Institution: University of Arizona

Technical Contact: Ilaria Pascucci, University of Arizona

Co-Investigators:
Daniel Apai, Steward Observatory
Michael Meyer, Steward Observatory
Jeroen Bouwman, Max Planck Institute for Astronomy

Science Category: circumstellar/debris disks
Dollars Approved: 43282.0

Abstract:
The first steps of planet formation are marked by the growth and crystallization of sub-micrometer-sized dust grains. These steps have been identified in disks around young stars of different masses and, recently, even in disks around brown dwarfs. Although models suggest that stellar age and luminosity alone shall determine the extent of dust processing, recent observations show that grain growth and crystallinity can be very different even for coeval disks around stars of similar spectral type. This indicates the presence of at least a third important parameter. A number of studies in the past pointed out that multiplicity could play a major role in the disk evolution. But theoretical models have not yet reached a consensus on the efficiency of planet formation in the presence of companions. We propose here to investigate the effects of stellar companions on the initial steps of planet formation in protoplanetary disks. Our work will provide fundamental constraints on theoretical models of planet formation in multiple systems as well set the frame for the correct interpretation of the numerous Spitzer studies of dust in circumstellar disks. We selected a statistically significant sample of coeval disks around low-mass stars with well-known multiplicity to test the hypothesis that multiple systems have more processed dust disks (micron-sized grains and crystals). We have identified 59 spectra in the Spitzer archive from three different programs that have sufficient signal-to-noise to meet our goals. We will reduce and analyze these spectra in the same manner and determine the amount of large-to-small grains and crystals via the spectral decomposition of the 10 micron silicate emission feature. Our Monte Carlo simulations and Kolmogorov-Smirnov tests show that we will be able, for example, to discriminate between two populations with 10% and 20% crystalline mass fractions at a confidence level of 99%.

Spitzer Space Telescope - General Observer Proposal #3558

Using Spitzer to Reveal the Connection between Disks, Stellar Rotation, and Binaries

Principal Investigator: Jenny Patience
Institution: Caltech

Technical Contact: Jenny Patience, Caltech

Co-Investigators:
Bruce Macintosh, Lawrence Livermore National Lab

Science Category: circumstellar/debris disks
Observing Modes: IracMap MipsPhot
Hours Approved: 15.1

Abstract:
Solar-type stars in the young clusters alpha Persei (90Myr) and the Pleiades (125Myr) are at a unique stage of evolution, distinguished by a large range of rotational velocities -- from 10 km/s to 200 km/s -- for stars ofsimilar mass. A possible explanation for this large dispersion involves a star-disk interaction that regulates the rotation rate, but no previous instrument has possessed the sensitivity to detect disk emission at the age and distance of these exceptional clusters. With the unprecedented sensitivity of Spitzer, we propose to use IRAC imaging and MIPS photometry to search for disk emission from rapid rotators and binaries in alpha Persei and the Pleiades. By combining the proposed data with slow rotators and single stars in the Legacy sample, we propose to investigate disk signatures as a function of stellar rotational velocity and binary separation.

Spitzer Space Telescope - General Observer Proposal #30763

Dust around solitary millisecond pulsars

Principal Investigator: George Pavlov
Institution: Pennsylvania State University

Technical Contact: George Pavlov, Pennsylvania State University

Co-Investigators:
Alex Wolszczan, Pennsylvania State University
Divas Sanwal, Johns Hopkins University
Marc Kuchner, NASA Goddard Space Flight Center

Science Category: circumstellar/debris disks
Observing Modes: IracMap
Hours Approved: 4.7

Abstract:
The existence of planets around the millisecond pulsar B1257+12 strongly argues that at least some of the millisecond pulsars are accompanied by protoplanetary or debris disks where the planets form. Solitary millisecond pulsars are the best candidates to search for such disks. Being spun up to millisecond periods by accretion during their binary phase, the pulsars can form a disk by capturing substantial amounts of dust when their companion is lost due to evaporation by pulsar radiation or due to a stellar collision. Such disks intercept a fraction of the pulsar radiation and re-emit it as infrared thermal radiation. Recent observations of pulsars and related objects suggest that we should expect relatively hot, low-mass disks, which are most luminous at a few micron wavelengths. Thus, we propose to observe a sample of solitary millisecond pulsars with IRAC. We expect these observations to provide first detection of millisecond pulsar disks, establish the disk properties and their dependence on the pulsar parameters, and elucidate the processes of planet formation.

Spitzer Space Telescope - General Observer Proposal #50771

Debris Disks: An Unbiased Nearby A Star Sample

Principal Investigator: Neil Phillips
Institution: Institute for Astronomy, Royal Obs. Edinburgh

Technical Contact: Neil Phillips, IfA, Royal Obs. Edinburgh

Co-Investigators:
Bill Dent, UK Astronomy Technology Centre
Brenda Matthews, Herzberg Institute of Astrophysics
Jane Greaves, University of St Andrews
Wayne Holland, UK Astronomy Technology Centre
Mark Wyatt, Institute of Astronomy, University of Cambridge

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 15.4

Abstract:
We wish to complete an unbiased volume-limited survey of nearby A star systems, using MIPS to search for warm debris disks around the remaining 49 such systems within 45pc not observed by Spitzer. This will almost double the number of A-type systems observed by Spitzer in this volume. The dust mass limit will be a few x 1e-4 Earth masses, limited only by the photospheric emission and calibration accuracy. This would form the first complete and systematic survey for debris around the nearest ~100 A stars. It would complement similar surveys of FGK stars being carried out with Spitzer. The targets are to be observed by a complementary sub-millimeter survey (mainly using SCUBA-2), and together these data will be used to search for debris dust over a very wide temperature range (20-400K). Moreover the results will be used to determine the dust temperature, and hence place estimates on the size of emitting region. The results will form a valuable legacy from Spitzer. Not only will they help to understand how and why debris is found in such systems (by correlating the presence of dust with other system parameters), but they will form a superb target list for followup imaging with high spatial resolution facilities in the future.

Spitzer Space Telescope - General Observer Proposal #3347

Evolution of Debris Disks around A Stars in Young Clusters

Principal Investigator: Catherine Pilachowski
Institution: Indiana University

Technical Contact: Catherine Pilachowski, Indiana University

Co-Investigators:
Carol Grady, Eureka Scientific, Inc.
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Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 12.1

Abstract:
The immediate goal of this proposal is to investigate evolution of debris disks as a function of stellar age by surveying samples of A stars in young clusters to identify far-infrared excesses. Our long-term goal is to explore the timescales over which debris disks may be cleared out by the formation of planets and by orbital migration, and how these processes mesh with the evolution of the gas, as sampled at optical and UV wavelengths. We are investigating these processes by examining late B and early A dwarfs in clusters ranging in age from a few million years up to 100 million years. Spitzer observations with MIPS are key to detecting the presence of debris disks through signature emission in the 25-160 micron regime. Infrared flux measurements will enable us not only to detect debris disks and determine the frequency of such disks as a function of stellar age, but also to begin to characterize the properties of debris disks as a function of age. Data on the relative frequency of debris disks as a function of age may constrain the time scale for formation and migration of giant planets in young solar systems, and may help to distinguish between two competing models of giant planet formation (core accretion vs. disk instabilities).

Spitzer Space Telescope - General Observer Proposal #50731

AU Mic Is Not Alone: New M Dwarf Debris Disks

Principal Investigator: Peter Plavchan
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Technical Contact: Peter Plavchan, California Institute of Technology

Co-Investigators:
Peter Plavchan, Michelson Science Center
Karl Staplfeldt, JPL
Geoff Bryden, JPL
Mike Werner, JPL

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 9.5

Abstract:
M dwarfs constitute ~70% of the stars in our local neighborhood, yet we know little about the frequency and evolution of debris disks and planetary systems for this diverse spectral class. Among the numerous M dwarfs sampled by Spitzer in the nearest 25pc, AU Mic remains a unique M dwarf with its debris disk, infrared excess, 12Myr age, flaring, and X-ray activity (Chen et al. 2005, Plavchan et al. 2005, Kalas et al. 2005, Gautier et al., 2007). Plavchan et al. (2005) proposed that stellar wind drag can account for the apparent dearth of mature M dwarf debris disks. To test this hypothesis, in Cycle-4 we have observed to date 10 of 22 X-ray saturated M dwarfs like AU Mic out to a median distance of 32pc. From these initial observations, we have discovered 3 new M dwarf debris disks (Plavchan et al. in prep.). We propose to expand our sample to a statistically robust sample size comparable to the number of observed mature M dwarfs (~40). We propose observe 15 more nearby X-ray saturated M dwarfs in Cycle-5. These late-type dwarfs have ROSAT detections indicative of saturated X-ray activity (F_X>8x10^-5 ergs/cm^2/s) and are consequently likely to both be young and lack significant radial winds. Compared to the relatively old population of nearby M dwarfs, circumstellar disks are more likely to both exist and persist around these stars. Combining our sample with previous Spitzer observations, we will constrain the age evolution, frequency, and dynamics of M dwarf debris disks to place into context disks around solar type stars.

Spitzer Space Telescope - General Observer Proposal #30223

A complete IRS survey of the evolution of circumstellar disks within 3 Myr: New clusters of sequential star formation in Serpens

Principal Investigator: Klaus Pontoppidan
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Paul Harvey, University of Texas
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Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 71.9

Abstract:
We have discovered a uniquely rich star-forming region covering ~0.5 sq. degrees in the Serpens molecular cloud using the Cores to Disks (c2d) Legacy program IRAC/MIPS maps. It contains three clusters apparently at different evolutionary stages, suggesting that sequential star formation has taken place. We propose to perform a complete spectroscopic survey of the young stars in the region covering the full luminosity range extending from intermediate-mass young stars down to brown dwarfs with disks. Due to the exceptionally high number of young stars in the region, the sample can be used to derive significant statistics on the physical and chemical properties of young stellar populations of different ages. The sample will therefore provide a calibration of the sequence of disk evolution within a few million years. In particular, the spectra will contain signatures allowing the detailed comparison of grain composition, crystallinity, size distribution as well as physical structure of the disks between different populations of young stars at a range of evolutionary stages from embedded objects to evolved disks with large inner holes. The sample can thus be used as a comparative template for numerous studies of the evolution of young low-mass stars and will help to constrain the timescales for grain growth and clearing of the inner disk regions. The proposed 125 stars with proto-planetary disks include 9 brown dwarf candidates as well as 4 sources with infrared excess, but with photospheric colors out to 10 micron, suggesting the presence of inner gaps in the disks, possibly caused by the presence of new-born planets. Because of the large potential interest from the community, we propose to make the data non-proprietary.

Spitzer Space Telescope - General Observer Proposal #50449

Big Disks or Big Winds: Distinguishing between Debris Disk Evolutionary Models

Principal Investigator: Luisa Rebull
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Technical Contact: Luisa Rebull, Spitzer Science Center

Co-Investigators:
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Mike Meyer, University of Arizona
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Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 17.4

Abstract:
Rapidly rotating, x-ray active, young low mass stars are much less likely to have detected debris disks than slowly rotating stars of the same age. Two very different physical models can explain this correlation. Very strong winds from these young stars may impart drag (similar to Poynting-Robinson effect - but from particles rather than photons) on small grains in the disk, clearing the disk of the particles that emit efficiently in the infrared and thus greatly reducing any IR excess. Or, the stars which had long-lived primordial disks during PMS evolution - and which became slow rotators by transferring their angular momentum to those disks - may preferentially form large planetesimal populations which subsequently collide and produce small grains, and hence massive primordial disks may naturally lead to more detectable debris disks. We believe that MIPS observations of a well-selected sample of young F dwarfs can provide data that should be able to discriminate between these two models - and we are requesting observing time to obtain those data. Evidence suggests that PMS disk-locking is effective for stars with masses up to about 1.6 Msun - i.e. for stars as early as F0 on the main sequence. Outer convective envelopes deep enough to generate significant stellar winds, however, only occur for stars later than spectral type F5. If winds are responsible for the observed correlation, then we should only see if for late type F dwarfs. If PMS disk-locking is the cause, we expect to see the effect throughout the whole F dwarf spectral type range.

Spitzer Space Telescope - General Observer Proposal #3501

Probing Dust Disks Around Nearby Stars with Gas Disk Signatures

Principal Investigator: Seth Redfield
Institution: McDonald Observatory, University of Texas

Technical Contact: Seth Redfield, McDonald Obs, U. Texas

Co-Investigators:
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Jacqueline Kessler-Silacci, University of Texas at Austin

Science Category: circumstellar/debris disks
Observing Modes: IracMap IrsStare MipsPhot MipsSed
Hours Approved: 9.5

Abstract:
The relationship between planet formation and circumstellar disks around young stars is likely to be an area that Spitzer observations will have a dramatic impact. Excellent sensitivity will enable detections of even the faintest infrared excesses from dusty disks. Arguably, the most famous dusty disk system is beta Pictoris, which has a strong infrared dust signature, but also shows variability in high resolution absorption spectra of Ca II and Na I. These short term variations are attributed to star-grazing cometary-like objects, or Faint Evaporating Bodies (FEBs). Unfortunately, circumstellar absorption features in optical spectra are only detected toward disks with edge-on orientations. However, uniting both the infrared photometry and optical spectra proved to be a powerful technique in developing a more complete understanding of beta Pic's circumstellar environment. Therefore, we propose Spitzer observations of four nearby stars that show similar gas disk signatures in high resolution optical spectra, and yet due to relatively poor sensitivity, IRAS detected only faint or marginal infrared excesses. We propose to utilize all of Spitzer's instruments to measure the fundamental physical properties of the circumstellar gas and dust. IRAC and MIPS observations will provide precise photometry to reconstruct the infrared spectral energy distribution in order to measure the size, density, and composition of the dusty disk. High resolution IRS observations should show features caused by crystalline silicates, such as forsterite, which are commonly observed in comets, a direct link with the FEBs that are causing the optical spectral variability. In addition to the Spitzer observations, we will monitor the Ca II and Na I variability in ultra-high resolution spectra obtained from McDonald Observatory. Together, these observations will probe the relationship between the gas and dust components of circumstellar disks, and provide important constraints on models of disk evolution and planet formation.

Spitzer Space Telescope - General Observer Proposal #40922

Disk characteristics of TW Hydrae Association brown dwarfs

Principal Investigator: Basmah Riaz
Institution: University of Delaware

Technical Contact: Basmah Riaz, University of Delaware

Co-Investigators:
John Gizis, Univ. of Delaware

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 1.9

Abstract:
We request Spitzer 70 micron observations of two brown dwarfs, 2MASSW J1207334-393254 (2M1207) and 2MASSW J1139511-315921 (2M1139), in the TW Hydrae Association (TWA). From our previous Spitzer observations, we had shown that 2M1207 shows excess in all of the IRAC and MIPS 24 micron bands, while 2M1139 shows a small excess at 24 micron, but none in the IRAC bands. Using these existing observations, we have tried to model the disk around 2M1207. While we are able to obtain a good fit using a disk mass of 10^(-5) Msun, an inclination angle of 63degree, and an outer disk radius of 100 AU, there are degeneracies in the values for these disk parameters. As our model fits indicate, the variations in the model SEDs for different values of these disk parameters are more evident at mid-IR wavelengths. Thus observation obtained for 2M1207 at 70 micron would help in narrowing down the range of possible values for these important disk parameters. For the case of 2M1139, a small excess is seen at 24 micron that is only ~1.8 times the expected photospheric emission. However, the SED for this brown dwarf up to 24 micron is very similar to TWA 7, for which a cool debris disk has been detected at 70 micron. TWA 7 also shows a very small excess (only ~1.1 times the expected photospheric emission) at 24 micron, but flares up at 70 micron. Thus we request 70 micron observation for 2M1139 in order to confirm the presence of a debris disk around this brown dwarf, similar to TWA 7. If the presence of such a disk is confirmed for 2M1139, then this would be the first transition disk detected yet among the sub-stellar members of TWA.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30156

Dust Properties in Bright, Nearby Debris Disks

Principal Investigator: George Rieke
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Technical Contact: Geoffrey Bryden, JPL

Co-Investigators:
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Karl Stapelfeldt, JPL
Geoffrey Bryden, JPL
David Trilling, Univ. of Arizona
Kate Su, Univ. of Arizona
Paul Smith, Univ. of Arizona

Science Category: circumstellar/debris disks
Observing Modes: MipsSed
Hours Approved: 18.1

Abstract:
While many debris disks have now been identified with Spitzer, the properties of the dust in these systems remain for the most part unexplored. An initial detection of excess at a single wavelength provides only an upper limit on dust temperature and a lower limit on the dust luminosity. With additional spectral information, the distribution of dust temperatures can be modeled in greater detail. With some assumptions for the grain properties, the orbital location of the dust can also be determined. A well-defined dust SED provides a direct assessment of the range of dust temperatures and can distinguish dust orbiting in a ring-like configuration from dust in a broadly dispersed disk. From several GTO and GO programs, we have identified the brightest nearby debris disks. We propose to use MIPS-SED spectra to determine the range of dust temperatures in these systems. Knowledge of the dust temperature distribution will greatly increase our understanding of each of these systems, from the dust grain properties up to the overall debris disk architecture.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30211

Probing planetary system formation with Spitzer: Debris disks around early F stars

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: David Trilling, University of Arizona

Co-Investigators:
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John Stansberry, University of Arizona
Kate Su, University of Arizona
Geoff Bryden, JPL
Karl Stapelfeldt, JPL

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 20.2

Abstract:
We propose to study 50 early F stars with a mean age around 3 Gyr at both 24 and 70 microns to measure the fraction of these stars that possess debris disks. This experiment will bridge the gap between debris disk results for A stars and Sun-like stars, and between young and old samples. Our observations are designed to detect the photosphere of each star with S/N > 3 and will therefore rigorously determine the presence or absence of excesses that suggest debris disks. There are three possibilities that can explain the presently observed data for A and Sun-like stars, and each predicts a different result for a population of 3 Gyr early F stars. Identifying which possibility best fits the observed early F star excess rate will help us to understand the dominant physical mechanism that governs the frequency of debris disks and planet formation.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30429

MIPS 24 micron Study of Debris Disks in Praesepe and Coma Berenices

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: Kate Su, The University of Arizona

Co-Investigators:
Kate Su, University of Arizona
James Muzerolle, University of Arizona
Nadya Gorlova, University of Arizona
John Stansberry, University of Arizona
Zoltan Balog, University of Arizona

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot MipsScan
Hours Approved: 18.3

Abstract:
Debris disks form when asteroidal-scale bodies collide or cometary objects evaporate, generating fragments that participate in cascades of further collisions, eventually producing significant amounts of dust grains that glow in the Spitzer bands. Therefore, debris disks are clear evidence that planetary objects are present, and provide a great opportunity to understand how a planetary system forms from a record of events in planetary-forming zones. Early Spitzer studies on debris disks around A-type stars show a general decline in the amount of excess emission with age; younger (age <500 Myr) stars exhibit excesses more frequently (~30%) and with higher fractional excess than do the older stars. Other results from studying the evolution of excesses around solar-type stars show a similar trend within the errors, suggestive of an independence of stellar mass and a critical transition in disk properties from 300 Myr to 1 Gyr, over which the 24 um excesses apparently disappear. Nevertheless, we do not have a good statistical significance for ages greater than 300 Myr. In this proposal, we will address the debris disk evolution in this important intermediate age (500-600 Myr) with MIPS 24 um observations of Praesepe and Coma Berenices clusters. These two clusters are ~600 Myr in age, coinciding with the era of Heavy Bombardment and settling down to set the stage for life in our Solar system. Our proposed observations will span a critical gap in debris disk studies by Spitzer, and help to understand the debris disk evolution in this important era.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30470

A 70 Micron Study of the Effects of Environment on Protoplanetary Disk Evolution

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: James Muzerolle, University of Arizona

Co-Investigators:
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Nuria Calvet, University of Michigan
Paola D'Alessio, Instituto de Astronomia UNAM
Lee Hartmann, University of Michigan

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 17.8

Abstract:
We propose to obtain 70 micron observations of a statistically significant and representative sample of disked young stars in order to test the effect of environment on disk evolution. Theories of the photoionizing influence of massive stars on disks predict significant changes in disk structure on short timescales, including truncation and enhanced dust settling. Irradiated disk models show that far-infrared wavelengths around 70 microns are the most sensitive to changes in disk emission brought about by such structural modifications. In order to test the theoretical predictions, we will observe two regions with different radiation environments, targeting objects known to possess disks based on our Spitzer GTO survey at shorter wavelengths. These earlier observations were relatively shallow and detected very little at 70 microns; the proposed program will be one of the deepest and most comprehensive studies of protoplanetary disks performed to date at this wavelength. The sample spans a representative range of stellar masses and 3.6-24 micron spectral slopes, with generally comparable properties between the two regions except for incident UV flux. With a combination of modeling and a statistical comparison of the two samples, we will determine any systematic differences in far-infrared flux emitted by the disks and assess the role of environment on their evolution.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30503

Characterizing Debris Disks Around Young Suns

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: Nadya Gorlova, University of Florida

Co-Investigators:
John Stauffer, JPL/Caltech
Nadya Gorlova, Steward Obs.
James Muzerolle, Steward Obs.
Luisa Rebull, SSC
Nick Siegler, Steward Obs.
Kate Su, Steward Obs.
Erick Young, Steward obs.

Science Category: circumstellar/debris disks
Observing Modes: IrsStare MipsPhot
Hours Approved: 22.9

Abstract:
There is geological evidence that in the first few hundred Myr of the birth of the Solar System there was an epoch of strong bombardment caused by the collisions between growing planetesimals. Spitzer has the capability to probe that epoch in other stars by observing dust emission from debris disks around young solar system analogs. The MIPS GTO and FEPS Legacy teams have carried out a 24 micron survey of debris disks in a number of rich open clusters, with ages ranging from a few to 100 Myr. However, only a few of these clusters are close enough to detect fluxes in the MIPS bands to photospheric levels in solar mass stars; even fewer are close enough (<160 pc) to study disk properties by means of IRS spectroscopy. This proposal consists of two parts. 1) We will build on our previous investigation of the Pleiades core where we discovered a few solar analogs with MIPS excesses signaling debris disks. The excess fraction is tentatively bigger than among older field stars. To confirm this conclusion, we propose to observe the remaining F-G stars that are situated in the Pleiades corona and thus less affected by interstellar cirrus. 2) We will obtain IRS spectra for debris candidates in the Pleiades (100 Myr) as well as in two other intermediate-age clusters -- IC 2391 (50 Myr) and M47 (80 Myr). Disk spectra will allow us to constrain the disk geometry and other properties of debris dust, and to search for correlations of theses properties with the spectral type/mass of the host star. The IRS sample includes a range of spectral types from A to G stars. This program will provide the first representative sample of dust emission spectra at the intermediate age of 50-100 Myr, which likely corresponds to the final stages of terrestrial planet formation.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30566

Completing the MIPS GTO Debris Disk Sample

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: Kate Su, The University of Arizona

Co-Investigators:
Kate Su, University of Arizona

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 5.3

Abstract:
We will measure 15 stars at 70 micron to add to our understanding of debris disk evolution. These stars either have poor Spitzer measurements due to instrumental problems, or have measurements with ISO that need to be confirmed. Most of them are late B or early A stars, and will add to the statistical robustness of our program concentrating on the evolution of disks around such stars with age.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40078

Debris disks in tight binary systems

Principal Investigator: George Rieke
Institution: University of Arizona

Technical Contact: David Trilling, University of Arizona

Co-Investigators:
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Steve Kortenkamp, PSI
Eric Jensen, Swarthmore
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Geoff Bryden, JPL

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 17.6

Abstract:
The majority of solar-type and earlier main sequence stars in the local galaxy are in multiple (binary or higher) systems. Understanding planet formation in binary systems is critical to an overall understanding of planet formation. We have recently completed a Spitzer/MIPS program to study the properties of debris disks in 69 "old" (>600 Myr) A3-F8 binary systems. Our most surprising result is that a very large fraction (57%) of observed binary systems with small (<3 AU) separations have excess thermal emission, implying circumbinary disks. This excess rate is substantially higher than the rate for single stars of comparable age and spectral type and is also higher than that for our larger binaries sample. This "excess of excess" for tight binaries appears to be a real effect but is formally only a 1.5-sigma departure from the single star rate. The small significance of our result is largely due to the small number of stars in the original survey, with just 21 tight binaries in that sample. We propose here to observe 40 additional small separation (<3 AU) binary systems in order to confirm our intriguing but statistically underwhelming result that tight binary systems have a very high incidence of debris disks. A secondary goal is to explore the dependence of the excess rate for tight binaries on spectral type and on system age. This may potentially help reveal which mechanisms are responsible for the tight binaries result. Our results will provide a sample of debris disks in tight binaries that, when taken together with the original sample, will motivate and inform theoretical models of planetary formation and evolution in binary systems.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40227

The nature of extreme IR excesses in two solar-type stars discovered by Spitzer

Principal Investigator: George Rieke
Institution: Steward Observatory, U. Arizona

Technical Contact: Nadya Gorlova, University of Florida

Co-Investigators:
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Zoltan Balog, Steward Observatory
Kate Su, Steward Observatory

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 2.0

Abstract:
We propose to obtain follow-up IRS spectroscopy for two members of the 30 Myr-old cluster NGC 2547 that show unusually strong infrared excess at 3.6-24 microns, based on our prior IRAC and MIPS imaging. The age of the stars in NGC 2547 corresponds to a critical epoch when rare violent impacts similar to the Moon creation event are most likely to occur. It is also an age when all known primordial accretion disks have dissipated, according to previous observations. The mid-IR excess for one of the proposed objects - solar-type member ID8 - may be a result of a recent massive planetesimal collision. It may also be one of the rare transitional disks where the outer regions of a primordial disk remain optically thick but the inner few AU have been rendered optically thin or completely cleared, for example by planetesimal growth or planet formation. The other object, ID9, is a later-type cluster member whose spectral energy distribution implies optically thick dust emission at a range of temperatures, similar to that seen around younger classical T Tauri stars; if confirmed, it would be by far the oldest known object of this type. We will use the mid-infrared spectra to constrain the dust temperature(s), composition, and grain size distribution from the continuum shape and 10 and 18 micron silicate emission features. By comparing the spectra of ID8 and ID9 to known classical T Tauri and debris disks, as well as to the dusty envelopes of evolved stars, we will be able to resolve the nature of the unusual excesses around these solar-type stars. If these are indeed protoplanetary disks, they will provide unprecedented new laboratories for understanding disk evolution and planet formation processes.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40326

Deep IRAC Survey of H and Chi Persei

Principal Investigator: George Rieke
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Technical Contact: Zoltan Balog, University of Arizona

Co-Investigators:
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Scott J. Kenyon, Smithsonian Astrophysical Observatory
Thayne Currie, Smithsonian Astrophysical Observatory
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Science Category: circumstellar/debris disks
Observing Modes: IracMap
Hours Approved: 8.4

Abstract:
At 13 Myr, h and chi Persei bridge the gap between T Tauri disks and older debris disks, probing an important transition for disk evolution and planet formation processes. These clusters are a unique laboratory at this age to provide insight into planet formation time-scales, disk transition time-scales, and to constrain disk evolutionary models. We propose a deep IRAC survey to examine the behavior of the excess fraction. We will probe how disks evolve as a function of stellar mass down to subsolar mass limits during the critical age when optically thick T Tauri disks transition to optically thin debris disks.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40395

Debris Disk Study of the Lindroos Sample

Principal Investigator: George Rieke
Institution: University of Arizona

Technical Contact: Kate Su, University of Arizona

Co-Investigators:
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Mark Wyatt, Instutute of Astronomy, University of Cambridge, U
David Trilling, Steward Observatory, University of Arizona

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 1.4

Abstract:
Debris disks resulte from planetary activity such as colliding planetesimal (asteroidal) bodies or out-gassing comets, and therefore are clear evidence that planetary objects are present and provide a powerful approach to study the formation of planetary systems. The findings of protoplanetary disks and extrasolar planets around binary/multiple stars imply that most sites of planet formation are in binary systems. There is evidence from our previous work that the incidence of debris-disk-excess emission is elevated in binaries. We are expanding this result in another proposal to study old binary systems. In this proposal, we propose to obtain MIPS 24 and 70 micron photometry of the remaining 6 binary systems selected from the Wyatt et al. (2003) Lindroos sample to study debris disk properties around intermediate-age, main-sequence binary stars.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40431

A Search for AU Mics out to 50pc

Principal Investigator: George Rieke
Institution: University of Arizona

Technical Contact: Peter Plavchan, California Institute of Technology

Co-Investigators:
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Geoff Bryden, JPL
Karl Staplfeldt, JPL
Angelle Tanner, Caltech/IPAC
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Science Category: circumstellar/debris disks
Observing Modes: IrsStare MipsPhot
Hours Approved: 14.1

Abstract:
Among the numerous M dwarfs sampled by Spitzer in the nearest 25pc, AU Mic remains a unique M dwarf with its debris disk, infrared excess, 12Myr age, flaring, and X-ray activity (Chen et al. 2005, Plavchan et al. 2005, Kalas et al. 2005, Gautier et al., submitted). Plavchan et al. (2005) proposed that stellar wind drag can account for the apparent dearth of M dwarf debris disks. To test this hypothesis, we propose to observe 24 K6-M4.5 X-ray saturated dwarfs like AU Mic out to a median distance of 32pc, including 8 within 25pc that are absent from prior Spitzer nearby star efforts. These late-type dwarfs have ROSAT detections indicative of saturated X-ray activity (F_X>8x10^-5 ergs/cm^2/s) and are consequently likely to both be young and lack significant radial winds. For GJ 842.2 with a known sub-mm excess (Lestrade et al. 2006), we will additionally obtain low-resolution IRS spectra to constrain the disk properties. Compared to the relatively old population of nearby M dwarfs, circumstellar disks are more likely to both exist and persist around these stars.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40454

Debris Disks around Low-Mass Stars

Principal Investigator: George Rieke
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Technical Contact: Geoffrey Bryden, Jet Propulsion Laboratory

Co-Investigators:
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Angelle Tanner, MSC/JPL
Geoffrey Bryden, JPL
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David Trilling, Univ. of Arizona

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 9.9

Abstract:
Surprisingly, mature low-mass stars do not seem to harbor debris disks. With the exception of a few stars in young clusters (e.g. AU Mic), no stars below ~0.75 solar masses have been identified as having infrared excess. This is in strong contrast with solar-type stars, which frequently have detectable dust emission even at ages of many Gyr. However, relatively few low-mass stars have been targeted (just 20 M stars with S/N > 3 at 70um, c.f. many 100's of F and G stars), giving considerable uncertainty to the strength of the trend, the stellar mass where its starts, and how sharp a cutoff might exist. We propose to observe a sample of 29 bright nearby M stars, more than doubling the current sample, in order to confirm and further quantify the apparent lack of dusty debris around these stars. The lack of IR excess around low mass stars, if confirmed, has important implications for understanding the formation and evolution debris disks. Among possible explanations for the observed trend are that 1) late-type stars simply do not have any colliding belts of planetesimals, 2) they lack gas giant planets that may be necessary to stir up these belts, or 3) low mass stars have strong stellar winds that efficiently remove the dust. Meanwhile other theories of debris disk evolution that are not strongly correlated with spectral type (e.g. planetesimal collisions stimulated by a passing field star) can potentially be ruled out. Given the correlation between planets and debris disks in many of these theories, providing constraints on the origin of IR excess emission will aid in our understanding of planet formation and, by linking theory with spectral type, may assist in future efforts to detect planets.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40464

Infrared Excesses in Two Notable Stars

Principal Investigator: George Rieke
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Michael Jura, Dept. of Astrnomy, UCLA
Kate Su, Steward Obs., University of Arizona
James Liebert, Dept. of Astronomy, University of Arizona

Science Category: circumstellar/debris disks
Observing Modes: IracMap MipsPhot
Hours Approved: 0.5

Abstract:
We propose to obtain IRAC and MIPS 24 micron photometry of J37 and PG 0950+139. J37 is a remarkable main-sequence F-type star with peculiar photospheric abundances that have been attributed to the accretion of an asteroid; can we detect circumstellar dust remnant of this event? PG 0950+139 is a hot white dwarf with a unique, compact ionized nebula. Is this nebular gas located in an extended disk orbiting the M-dwarf companion to the hot star, and can we detect infrared emission from dust in this disk?

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40679

Debris Disk Legacy

Principal Investigator: George Rieke
Institution: University of Arizona

Technical Contact: Kate Su, University of Arizona

Co-Investigators:
Kate Su, Steward Observatory, University of Arizona
Karl Stapelfeldt, Caltech/JPL
Mark Clampin, Goddard Space Flight Center
Geoff Bryden, Caltech/JPL
Peter Plavchan, Caltech/IPAC
Andras Gaspar, University of Arizona
Paul Smith, Steward Observatory, University of Arizona

Science Category: circumstellar/debris disks
Observing Modes: IrsStare MipsPhot MipsSed
Hours Approved: 11.1

Abstract:
Our main focus is to complete the suite of Spitzer data on debris disks that have been resolved in scattered light. The images of these disks provide information on their structures that can be used to constrain models of their spectral energy distributions. However, there are no MIPS SED mode observations for at least half of the systems resolved in scattered light. By obtaining such observations and combining them with existing IRS low resolution spectra, we will obtain well-sampled SEDs for our modeling. The result should be a suite of much better constrained and hence more realistic models than exist for most debris systems. These models can also be used to learn more about the strengths and weaknesses of models based on SEDs alone, without resolved images. These models will be further refined when after the launch of Herschel with SPIRE low resolution spectra. The MIPS data are essential to avoid a gap from 35 to 200 microns in the well samples regions of the SEDs of these important debris systems. In addition, we will fill in significant omissions in the data for a few debris disks, and will repeat data where there are important discrepancies. This program will therefore take a step toward leaving a solid legacy from Spitzer to debris disk observations with Herschel/SPIRE and JWST/MIRI.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40

Debris Disk Evolution in A stars

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: Kate Su, The University of Arizona

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 36.6

Abstract:
We defined this program by hypothesizing that debris disks would have completed any significant evolution by the time they had aged to a few hundred million years, and that we therefore needed to study a sample of stars out to about 1 Gyr. A stars provide a high luminosity probe where surrounding material is easily visible over this age range. We also set the requirement that MIPS should be able to detect the stellar photosphere at 70um, equivalent to requiring that the star be brighter than about 7.4 magnitude, or for main sequence A stars, that the star be closer than about 170pc. A separate sample was selected for which MIPS should be able to detect the photosphere at 160mm, requiring the star to be brighter than about magnitude 3.5. Ages have been estimated from cluster membership, association with moving groups, or Stromgren photometry combined with Hipparchos distances. The stars have been screened for relatively low columns of atomic hydrogen. We have coordinated with a similar program by Michael Jura to provide more intense sampling at young ages. Our total sample is about 140 objects, with a similarly sized sample in his program.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #41

A Volume Limited Sample of Nearby Stars

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: Charles Beichman, JPL

Science Category: circumstellar/debris disks
Observing Modes: IrsStare MipsPhot MipsSed
Hours Approved: 85.6

Abstract:
The primary goal of the Volume Limited Sample (VLS) is to look for emission in the wavelength range from 15-160 um from solid material orbiting stars at distances of a few to a few hundred AU. Because SIRTF cannot, in most cases, resolve spatially these disks, we will make a photometric and spectro-photometric survey looking for excesses over the emission expected from the photosphere. Our ability to identify small excesses will be limited by signal-to-noise, calibration effects and photospheric models. We will make photometric measurements down to a fraction of the expected photospheric level at 24 um (~1% from photon statistics but realistically to a few percent given calibration uncertainties) and 70 um (4%, 1 sigma). To detect very cold dust and/or the largest dust grains and to provide a linkage to ground-based submillimeter measurements, we will make measurements at 160 um down to the extra-galactic confusion limit. Spectro-photometry offers a powerful method of identifying weak excesses. The VLS program uses both IRS Long-Lo (to 4% of the photosphere at 40 um) and MIPS SED (to 4% on the photosphere at 70 um on the brightest members of the sample). The spectroscopy of detected disks will constrain the spatial distribution and composition of the dust.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50150

IRS observations of debris disks: Studying the global properties of debris disks with a complete Spitzer sample

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: David Trilling, University of Arizona

Co-Investigators:
David Trilling, University of Arizona
Kate Su, University of Arizona
Karl Stapelfeldt, JPL
Peter Plavchan, IPAC
Thayne Currie, CfA
Carey Lisse, JHU/APL
Geoff Bryden, JPL
Farisa Morales, JPL
John Stansberry, University of Arizona

Science Category: circumstellar/debris disks
Observing Modes: IrsStare MipsPhot
Hours Approved: 12.0

Abstract:
Observations of debris disks allow us to characterize planetary system formation across a wide range of spectral types. MIPS has been used extensively to detect debris disks. However, models of these debris disks are extremely degenerate. We propose here to make IRS long-low observations of 62 of these MIPS-measured debris disks systems. The data will be used to constrain the physical properties of those debris disks. We will combine these new data with existing data from our team and from the archive to produce a catalog of ~150 debris disks and their properties. We will use this catalog to study the global properties of debris disks. Only a large catalog such as this one will ultimately be useful for understanding the process of planetary system formation across a range of stellar types. The IRS data are essential for such studies because they describe the spectral energy distribution that originates from the inner zones of debris disks and rings. For many of these systems, the observational signature of the disks become detectable at 30--40~microns. IRS long-low spectroscopy in Spitzer Cycle 5 is the last chance for a generation to characterize this emission and the planetary system properties that correspond.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50169

Confirmation of High Frational Luminosity Debris Disk Candidates

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: Kate Su, The University of Arizona

Co-Investigators:
Kate Su, Steward Observatory

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 3.3

Abstract:
We propose to obtain MIPS 24 and 70 micron observations of 14 IRAS and ISO identified, high-fractional-luminosity, infrared-excess stars to confirm the nature of their possible debris disks.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50175

Diversity of Debris Disks - Constraining the Disk Outer Radii

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: Kate Su, The University of Arizona

Co-Investigators:
Kate Su, Steward Observatory, University of Arizona
Paul Smith, Steward Observatory

Science Category: circumstellar/debris disks
Observing Modes: MipsSed
Hours Approved: 18.9

Abstract:
Existing Spitzer observations of debris disks show a wide range of diversity in disk morphologies and spectral energy distributions (SEDs). The majority of debris disks observed with Spitzer are not resolved, resulting in very few direct constraints on disk extent. In general, SEDs alone have little diagnostic power beyond some basic statistics. However, as demonstrated by some Spitzer observations of nearby systems (beta Leo and gamma Oph), the spectra of the excess emission in the IRS and MIPS-SED wavelength range can help to put tighter constraints on disk properties such as minimum/maximum grain sizes and inner/outer disk radii. The dust continuum slopes are very useful to differentiate between various disk structures and constrain the dust mass. We need to study sufficient numbers of disks to explore their characteristics systematically. Therefore, we propose to obtain MIPS-SED observations of 27 debris disks that already have IRS-LL spectra and MIPS 24 and 70 micron photometry.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50263

Investigating the observable signatures of planet formation: Spitzer observation of the 10 Myr open cluster NGC 6871

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: Zoltan Balog, University of Arizona

Co-Investigators:
Scott J. Kenyon, Smithsonian Astrophysical Observatory
Thayne Currie, Smithsonian Astrophysical Observatory

Science Category: circumstellar/debris disks
Observing Modes: IracMap MipsScan
Hours Approved: 9.7

Abstract:
We propose a deep IRAC/MIPS survey of NGC 6871, a ~10 Myr-old massive cluster unexplored in the mid infrared. This cluster is at a key stage in terrestrial planet formation. Our survey will likely detect infrared excess emission from debris disks and transition disks from ~ 100 intermediate-mass (1-3 solar mass) stars. Together with ground-based photometry/spectroscopy of this cluster, proposed observations of 20 Myr-old NGC 1960, scheduled cycle 4 observations of the massive 13 Myr old clusters h and chi Persei, and existing data on NGC 2547 at 30 Myr, this survey will yield robust constraints on the frequency of debris/transition disks as a function of spectral type, age, and cluster environment at a critical age range for planet formation. This survey will provide a benchmark study of the observable signatures of terrestrial planet formation that will inform James Webb Space Telescope observations of planet-forming disks a decade from now.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50265

Investigating the observable signatures of planet formation: Spitzer observation of the 20 Myr open cluster NGC 1960

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: Zoltan Balog, University of Arizona

Co-Investigators:
Scott J. Kenyon, Smithsonian Astrophysical Observatory
Thayne Currie, Smithsonian Astrophysical Observatory

Science Category: circumstellar/debris disks
Observing Modes: IracMap MipsScan
Hours Approved: 9.7

Abstract:
We propose a deep IRAC/MIPS survey of NGC 1960, a ~20 Myr-old massive cluster unexplored in the mid infrared. This cluster is at a key stage in terrestrial planet formation. Our survey will likely detect infrared excess emission from debris disks and transition disks from ~ 100 intermediate-mass (1-3 solar mass) stars. Together with ground-based photometry/spectroscopy of this cluster, proposed observations of 10 Myr-old NGC 6871, scheduled cycle 4 observations of the massive 13 Myr old clusters h and chi Persei, and existing data on NGC 2547 at 30 Myr, this survey will yield robust constraints on the frequency of debris/transition disks as a function of spectral type, age, and cluster environment at a critical age range for planet formation. This survey will provide a benchmark study of the observable signatures of terrestrial planet formation that will inform James Webb Space Telescope observations of planet-forming disks a decade from now.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50302

160 micron Photometry of A star Power Laws

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: Farisa Morales, JPL

Co-Investigators:
Michael Werner, Jet Propulsion Laboratory
Karl Stapelfeldt, Jet Propulsion Laboratory
Geoffrey Bryden, Jet Propulsion Laboratory
Kate Su, University of Arizona

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 5.6

Abstract:
We propose 160 um imaging for a sample of 4 planetary debris disks around main-sequence A stars, with MIPS 24 and 70 um excess, and for which the 5-35 um IRS data are best fit by power-laws of slopes ranging from 1.1 to 2.4. By extending our observations out to 160 um, we may find evidence for substantial reservoirs of colder material that considerably outweighs the warmer material seen shortward of 70 um. Other debris disks do not show evidence for such SEDs, nor for such large amounts of cold material. It is not clear whether this difference is due to the greater luminosity of the A stars, their higher mass and light/mass ratio, or their naturally younger ages, but we may be able to explore this interesting question. The result of these measurements will be an SED that extends over a factor of 10 in wavelength and as much as a factor of 100 in radial distance from the star. This broad range of spectral coverage can be used to test models of the structure and evolution of debris disks and their underlying planetary systems.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50306

Searching for the Missing Component - Small Grains in Debris Disks

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: Kate Su, The University of Arizona

Co-Investigators:
Kate Su, Steward Observatory

Science Category: circumstellar/debris disks
Observing Modes: MipsScan
Hours Approved: 14.4

Abstract:
Debris disks provide a unique tool to probe the violent history of terrestrial planet formation and evolution. It is believed that terrestrial planets form on time scales of 10-30 Myr through collisions of planet embryos. Secondary collisions induced in the remaining planetesimals can continue for a few hundred million years. During this violent phase, a large fraction of the mass in the planetesimals is converted into debris. The unexpected large disk found in the Vega system suggests that the fine debris generated in these violent events can be traced as an outflow disk, consisting small grains ejected by photon pressure. In this program, we propose to search for the clouds of fine debris around 5 nearby debris disks. The outcome of the program will be used to estimate the frequency of major planetesimal collisions.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50316

Young Stellar Associations Cleanup: A Deep Circumstellar Disk Census at Ages 8-12 Myrs

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: Karl Stapelfeldt, Jet Propulsion Laboratory

Co-Investigators:
Karl Stapefeldlt, Jet Propulsion Laboratory
Peter Plavchan, Jet Propulsion Laboratory
Luisa Rebull, Spitzer Science Center
Dean Hines, Space Sciences Incorporated

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 17.4

Abstract:
The transformation of primordial protoplanetary disks into optically thin debris disks takes place very early in a star's life. The youngest debris disks are therefore of great interest for disk evolution studies, as their properties can define the mechanisms and timescales for planet formation. In the age range 8-12 Myrs, three nearby young stellar associations are crucial to these studies: eta Chamaeleontis, TW Hydrae, and beta Pictoris. Spitzer/MIPS studies of these groups have found that both optically thick and thin disks are present at 8 Myrs, but only optically thin disks at 12 Myrs. Disk inner holes, diagnosed by the presence of 70 micron excess and absence of 24 micron excess, are found so far in only the beta Pictoris group. Disk fractions of 30-50% have been measured at 24 microns down to the photospheric limit. However, at 70 microns, the existing data are relatively shallow, probing to only to 3-20 times the photospheric limit, and providing a lower limit to the disk fraction > 30%. We propose to obtain much deeper measurements (10 cycles of 70 micron photometry) for 37 members of these groups not yet detected at 70 microns, and which are found in regions of low to medium background emission, In addition, we include 24 micron observations for two eta Cha members that fell outside the scan map region in the original study. The results of this program will allow an assessment of the frequency of disks down to Ld/Lstar ~0.0002 across the full membership of these young associations, thereby consolidating the Spitzer science legacy for early disk evolution.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50370

AU Mic Is Not Alone: Characterizing New M Dwarf Debris Disks

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: Peter Plavchan, California Institute of Technology

Co-Investigators:
Peter Plavchan, Michelson Science Center
Mike Werner, JPL
Geoff Bryden, JPL
Karl Staplfeldt, JPL

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 3.2

Abstract:
M dwarfs constitute ~70% of the stars in our local neighborhood, yet we know little about the frequency and evolution of debris disks and planetary systems for this diverse spectral class. We have discovered three new M dwarf debris disks with our Cycle-4 Spitzer program observing X-ray saturated, nearby, young M dwarfs. We propose to confirm the excesses with IRS observations, and to constrain disk properties from the SED. Combining our sample with previous Spitzer observations, we will constrain the age evolution, frequency, and dynamics of M dwarf debris disks to place into context disks around solar type stars.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #52

Circumstellar Environments of the Nearest Stars

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: Nick Gautier, JPL

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 27.4

Abstract:
The Sun's nearest neighbors are predominantly cool, low-mass dwarf stars. These objects are likely to harbor circumstellar disks or substellar companions that have gone undetected in previous searches. Only a dozen of the nearest M dwarfs were bright enough to allow IRAS detections of their photospheres, and only a single one was measured well enough to suggest an infrared excess. The nearest stars offer SIRTF its best opportunity to address two important science goals: (1) Measure the frequency and nature of infrared excess among M dwarfs, the most common stellar type in the galaxy; and (2) Conduct an imaging search for substellar companions as small as ten Jupiter masses at SIRTF's maximum linear resolution, with minimal required image contrast. The results of this program will provide important supporting information for future planet searches in the solar neighborhood. This program explicitly includes all stars within 5 pc of the Sun which are not targeted in other MIPS GTO programs, a total of 45 targets. All are M dwarfs, with the exceptions of alpha Cen, Sirius, and Altair. Similar programs are planned for these targets by the IRAC and IRS teams, and will be coordinated with this effort.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #54

Binary Star Debris Disk Survey

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: John Stansberry, The University of Arizona

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 21.8

Abstract:
The purpose of this project is to quantify the frequency with which debris disks occur in binary star systems, and to obtain an initial characterization of those disks which are discovered. We will obtain 24 and 70 micron MIPS photometry of about 40 nearby binary star systems in order to address these goals. While there are mainsequence binary systems with IR excesses, little is know about whether those excesses are attributable to disks, or the nature of the disks which may be involved. The question of whether and how binary star systems form and retain disks is intimately linked with the question of the occurrence of planets in binary star systems because of the genetic link between disks and planets. Our target list samples binary separations in the range 1-500 AU, with a preponderance of targets in the dynamically interesting range 10-100 AU. The signal to noise of the measurements will be about 20 relative to the photospheric emission of the primary star to give good sensitivity to disks and to maintain a photometric sensitivity which is consistent with that of the Volume Limited Sample project.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #57

Connecting Images and SEDs in Bright Debris Disks

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: Karl Stapelfeldt, Jet Propulsion Laboratory

Science Category: circumstellar/debris disks
Observing Modes: IracMap MipsPhot MipsSed
Hours Approved: 12.9

Abstract:
To identify systems with disks resolvable by MIPS, a list of infrared excess stars with well-determined distances was compiled from the Backman & Paresce lists and published ISO results. Using each object's distance and luminosity, the angular size of the 40 K emission region (the temperature of a blackbody whose peak emission falls in the MIPS 70 mm band) was calculated. The list was ranked from the largest to smallest potential angular sizes, and cut off at a disk radius of 10" (corresponding to two pixels in the MIPS 70 mm super-resolution mode). This list consists of 16 sources, mostly A stars due to their greater luminosity. This program will obtain imaging data on the stars not already included in other programs. For each source, the intention is to obtain imaging photometry in the 24 mm and 160 mm MIPS bands, plus 70 mm super-resolution images and SED mode. An observing strategy in common with the MIPS volume limited survey program will be used. These sources are also being observed spectroscopically in a separate but coordinated program by the IRS team.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #58

Evolution and Lifetimes of Protoplanetary Disks

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: Erick Young, The University of Arizona

Science Category: circumstellar/debris disks
Observing Modes: IracMap IrsStare MipsScan
Hours Approved: 81.0

Abstract:
The goal of our study is twofold. First, we intend to determine the frequency and duration of the protoplanetary disk phase of evolution and thus directly constrain the probabilities and timescales for the formation of the major planetary bodies. Second, we intend to investigate the timescale for and nature of the transition to the debris disk phase of disk evolution. To achieve these goals we intend to survey a sample of young stellar clusters of varying age, richness and stellar content. We will determine disk frequency by measuring the amount of infrared excess toward every resolved star in each of our clusters. The primary wavelength of the survey will be 24 microns. Since the observations will be done in MIPS scan map mode, concurrent observations at 70 and 160 mm will be made. Additionally, for many of the clusters, we will coordinate observations with the IRAC team to obtain photometry at 3.5, 4.5, 6.3, and 8 mm. Our sample consists of clusters ranging in age from 1-100 million years.

Spitzer Space Telescope - General Observer Proposal #20280

Determining the Disk Fraction Among Shell Stars : A Survey for Circumstellar Disks with Gas and Dust

Principal Investigator: Aki Roberge
Institution: Carnegie Institution of Washington

Technical Contact: Aki Roberge, Carnegie Institution of Washington

Co-Investigators:
Alycia J. Weinberger, Carnegie Institution of Washington - DTM

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 12.6

Abstract:
Long before the canonical debris disk Beta Pictoris was known to be a young planetary system harboring evaporating and colliding planetesimals (a debris disk), it had been classified as a shell star. This peculiar class consists of stars with narrow absorption lines in their spectra, which are thought to arise from circumstellar gas. In the last several years, some of the main sequence shell stars have turned out to have protoplanetary or debris disks. The fraction of main sequence shell stars which are actually young disk systems is not known, but appears to be at least 22%. We propose a MIPS photometric survey of main sequence shell stars to determine the disk fraction. These observations will look for IR excess emission associated with circumstellar dust disks. If we find that there are young disk systems still hiding among the main sequence shell stars, this project will dramatically expand a rare and valuable set of disks where the gas and dust may be studied together. This will allow the first statistically significant examination of the co-evolution of gas and dust throughout the planet formation phase.

Spitzer Space Telescope - Directors Discretionary Time Proposal #475

Ices in the Solar Nebula

Principal Investigator: Sarah Robinson
Institution: UCO/Lick Observatory

Technical Contact: Sarah Robinson, UCO/Lick Obs.

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 12.0

Abstract:
The centerpiece of this proposal is my hypothesis that other ices besides H2O help build giant planet cores. I propose a theory project on the ice composition of planet-forming regions and a related observing project on ice detection and mineralogy in debris disks. Together, the theory and observing projects will answer two questions: 1. Where are the condensation fronts of abundant volatiles located in relation to giant planet feeding zones? 2. How much does the presence of CHON ices in planetesimals speed up giant planet formation?

Spitzer Space Telescope - Directors Discretionary Time Proposal #255

Spitzer Observations of a Newly-Discovered Nearly Edge-On Disk About HD 32297

Principal Investigator: Glenn Schneider
Institution: UNIVERSITY OF ARIZONA

Technical Contact: Dean Hines, Space Science Institute

Co-Investigators:
Dean Hines, Space Science Institute
Murray Silverstone, U. Arizona
Thomas Henning, Max-Planck-Institut fur Astronomie, Heidelberg
Sebastian Wolf, Max-Planck-Institut fur Astronomie, Heidelberg
Francois Menard, Laboratoire d'Astrophysique
Carol Grady, Eureka Scientific

Science Category: circumstellar/debris disks
Observing Modes: IracMap IrsStare MipsPhot
Hours Approved: 1.1

Abstract:
We request 1.1 hours of Spitzer Director's Discretionary time to obtain IRAC and MIPS imaging photometry and IRS low resolution spectroscopy of a newly discovered, nearly edge-on, debris disk around HD 32297. The disk, discovered in our currently executing HST/NICMOS GO 10177 coronagraphic survey program, extends at least 3.3" (400 AU) from the star along its major axis and has a 1.1 micron flux density of F(1.1 micron) = 4.81 +/- 0.57 mJy beyond 0.3". Although providing crucial information on the disk morphology and dust scattering efficiency, our scattered light image cannot unambiguously inform on the physical properties of the dust in this potentially planet-forming environment. Thermal emission from the disk was detected at 25 + 60 microns with IRAS, but these measures alone permit only a very rudimentary thermal model of the system, leaving many degeneracies that allow a large range of particle sizes and disk masses. No other IR photometry is available, and indeed this object has been largely ignored in the past at all wavelengths. To further elucidate the physical characteristics of the disk and its constituent grains, we propose to obtain photometry and spectra from 3.6 - 160 microns with the Spitzer Space Telescope. This will allow us to develop a well-sampled spectral energy distribution (SED) for both the star and the disk emission, including mid-IR spectral coverage sufficient to characterize mineralogical features that will place strong constraints on the dust constituents. In addition, the large angular extent of the disk makes it one of the few known systems that can be spatially resolved in thermal emission with Spitzer (at wavelengths < 24 micron). Given the 1.1 microns scattering fraction of f(disk)/f(star) = 0.33% (from our NICMOS observations), an IRAS F(60 micron) = 1.12 Jy, and a 25 + 60 microns fractional dust emission excess luminosity of L(ir)/L(star) ~ 0.27%, this object is easy to observe with Spitzer and will consume minimal resources. As one of only a small handful of disks resolved

Spitzer Space Telescope - General Observer Proposal #30395

A disk survey at the bottom of the IMF

Principal Investigator: Alexander Scholz
Institution: University of Toronto

Technical Contact: Alexander Scholz, University of St. Andrews

Co-Investigators:
Ray Jayawardhana, University of Toronto

Science Category: circumstellar/debris disks
Observing Modes: IracMap
Hours Approved: 12.0

Abstract:
Young brown dwarfs share many properties with classical T Tauri stars. In particular, many of them harbour T Tauri like accretion disks, detected by colour excess in the infrared. Disk frequency and properties do not appear to be significantly different from young solar-mass stars, implying that brown dwarfs probably form in a way similar to stars. Here we propose to probe if the same holds for even lower mass objects with masses below or around the Deuterium burning mass limit of ~12 Mjup. These "isolated planetary mass objects" (IPMO) or "sub brown dwarfs" are the lowest mass isolated objects identified so far, and thus represent the bottom of the IMF. It is unknown if they are the very low mass end of the outcome of the star formation process, ejected stellar embryos, or even ejected giant planets. Since IPMOs are extremely faint in the optical and the near-infrared, studying their mid-infrared properties is one of the very few ways to constrain their origin and early evolution. Recently, a disk has been detected around one IPMO in Chamaeleon, using Spitzer IRAC photometry. We propose to use the same approach to investigate a large sample of 24 IPMOs in young open clusters in Orion. Using the outstanding sensitivity and unique wavelength coverage of IRAC, we will be able to identify how many IPMOs show a disk signature, and derive, for the first time, the disk frequency for this object class. This will allow us to set first constraints for formation scenarios in the IPMO mass range.

Spitzer Space Telescope - General Observer Proposal #30523

Dust and Gas in Planet-Forming Disks: Tracing the Grains in Transitional and Evolved Systems

Principal Investigator: Aurora Sicilia-Aguilar
Institution: Max-Planck-Institut fuer Astronomie

Technical Contact: Aurora Sicilia-Aguilar, MPIA

Co-Investigators:
Thomas Henning, Mak-Planck-Institut fuer Astronomie, Heidelberg
Lee Hartmann, University of Michigan
Jeroen Bouwman, Mak-Planck-Institut fuer Astronomie, Heidelberg
Dan Watson, University of Rochester
Chris Bohac, University of Rochester

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 37.9

Abstract:
DWe present a sample of low-mass stars with disks in the Cep OB2 region, members of the young clusters Tr 37 (~4 Myr) and NGC 7160 (~12 Myr). These stars have been studied in detail using optical photometry and spectroscopy, determining membership for stars with and without disks, spectral types, ages, the presence of accretion, and the accretion rate and/or its upper limits. Because of their critical ages for planet formation, they were included in a GTO program with IRAC and MIPS. These observations revealed disk fractions of ~45% for Tr 37, and ~4% for NGC 7160, evidence of inner disk evolution in about 95% of the disks, and inner gaps in about 10% of them. Given that the dust composition and sizes, as well as the most detailed disk structure (presence of gaps and walls, dust temperatures) cannot be derived from the SEDs only, we propose to obtain IRS spectra of a large (statistically significant) and unbiased sample of these stars with well-known accretion and stellar properties. This relatively short program is crucial to study the dust characteristics in stars that are probably ongoing active planet formation, the dust settling/grain growth, the opening of gaps at few AU distances, the possible correlation between dust and gas (accretion) evolution, and it will complete our understanding of disks evolution by constraining the parameters involved in disk models.

Spitzer Space Telescope - General Observer Proposal #3600

Disk Census of Nearby Young Stellar Groups

Principal Investigator: Inseok Song
Institution: University of California, Los Angeles

Technical Contact: Inseok Song, University of California, Los Angeles

Co-Investigators:
Ben Zuckerman, UCLA
Mike Bessell, Australian National University

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 10.7

Abstract:
MIPS 24 and 70 micron observations are proposed to detect infrared excess emission at ~50 members of nearby, young stellar groups. Ages of these stars are well determined and the age range (8-50 Myr) overlaps with important epochs of our own Solar System formation. Using a high fidelity spectral energy distribution fitting technique, photospheric fluxes will be estimated with uncertainty as small as ~10mJy. Sensitive Spitzer observations with accurate photospheric flux estimates will allow us to assess IR excesses as small as L(IR)/L(star)~10^-5 for late-type stars. For early-type stars, we can detect excess emission as small as 10^-6. These observations will provide a wide range of dust excess over the interval 8-50 Myr for stars with spectral types from B to M. Together with data from Spitzer legacy and GTO programs, this proposed study can significantly improve our understanding of the diversity and frequency of dusty disk occurrence among young stars and provide important information on formation and early evolution of planetary systems.

Spitzer Space Telescope - General Observer Proposal #50228

IRS View of a Planetary Collision in the Pleiades

Principal Investigator: Inseok Song
Institution: University of California, Los Angeles

Technical Contact: Inseok Song, University of California, Los Angeles

Co-Investigators:
Joseph Rhee, UCLA, Physics and Astronomy
Ben Zuckerman, UCLA, Physics and Astronomy
Carey Lisse, Johns Hopkins University, Applied Physics Lab

Science Category: circumstellar/debris disks
Observing Modes: IracMap IrsStare
Hours Approved: 0.7

Abstract:
Recently, we identified a sun-like Pleiades member, HD 23514, hosting a huge quantity of warm dust grains. Next to BD+20 307 (a field sun-like star), HD 23514 is currently the second dustiest, adolescent-age, star known with warm excess IR emission. Very short removal timescales of warm dust grains and adolescent ages of these two stars (>~100 Myr) indicate that the very dusty, warm excess, phenomenon is a transient event. A catastrophic collision between planetary embryos or planets is the most plausible origin of so much warm dust and such a collision mimics the postulated Moon-creation event in our terrestrial system. But the N-band spectra of BD+20 307 and HD 23514 appear very different, with peculiar emission at HD 23514 peaking at ~9 microns, a peak wavelength hardly seen among young stars and other main sequence excess stars. The strange N-band spectrum may point to an extra-ordinary condition around HD 23514 such as a very thick crust of a planet, a freakish chemical composition, or shocked silicates from a planetary collision. An IRS spectrum covering the 5-35um spectral range, rather than the highly restricted ground-based N-band spectrum will provide much stronger and clearer constraints on the dusty environment of HD 23514. We propose IRS observations with all four low resolution modules to obtain a diagnostic mid-IR spectrum of this rare, fascinating star.

Spitzer Space Telescope - General Observer Proposal #50554

Do massive primoridial disks evolve into massive debris disks?

Principal Investigator: Inseok Song
Institution: University of California, Los Angeles

Technical Contact: Inseok Song, University of California, Los Angeles

Co-Investigators:
John Stauffer, SSC/Caltech
Ben Zuckerman, UCLA, Physics and Astronomy
Luisa Rebull, SSC/Caltech
Mike Bessell, Australian National University

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 13.6

Abstract:
A strong link between primordial circumstellar disks and stellar rotation has been established recently from Spitzer IRAC observations of young stars in Orion and NGC 2264. A larger percentage of stars with excess IR emission is seen among slower rotators than among fast rotators. This has been interpreted to indicate that stars with more prominent disks lose their angular momentum via a "disk locking" mechanism and become slow rotators. If stars with massive primoridial disks evolve into massive debris disks, then massive debris disks should be more frequent among slow rotators. On the other hand, stars that have lost their disks early or are born with much less massive disks could spin-up freely and become fast rotators, hence weak debris excess or non-excess stars at later stage. With the established link between stellar rotation and primordial disks and with sensitive MIPS 24/70 data for a large sample of post-accretion phase young stars, we can now test, observationally, whether massive prolonged primordial disks evolve into massive debris disks.

Spitzer Space Telescope - General Observer Proposal #50033

Binary Debris Disks: Follow-on Observations of Spitzer Discoveries

Principal Investigator: John Stansberry
Institution: The University of Arizona

Technical Contact: John Stansberry, The University of Arizona

Co-Investigators:
David Trilling, Univ. Arizona
Karl Stapelfeldt, JPL
Katherine Su, Univ. Arizona
Eric Jensen, Swarthmore College
George Rieke, Univ. Arizona
Robert Mathieu, University of Wisconsin
Nader Haghighipour, Univ. Hawaii
Stephen Kortenkamp, Planetary Sci. Institute

Science Category: circumstellar/debris disks
Observing Modes: IrsStare MipsPhot
Hours Approved: 9.1

Abstract:
We have completed a MIPS survey for debris disks in 63 A5-F5 main sequence binary systems having separations of 0 - 500 AU, placing the secondary within the planet-forming zone. All targets were detected at 24um; at 70um we observed 50 of the targets, detecting 50 of those at SNR > 3. A surprising result of the survey is that 18 of those systems (36%) display 70um emission in excess of the photospheres, a rate is larger than that seen for single stars of comparable age. The 9% excess rate we found at 24um is also high by that comparison. To explore this difference, we propose to complete the initial survey at 70um, and to refine the results for the systems that show excess emission. The systems lacking 70um data ~all have separations > 5 AU: completing the sample will balance the larger number of systems with 70um data and separations < 5AU. These data will provide the control sample for an approved MIPS cycle 4 survey of 50 close binaries, provide the link to existing results for single stars, and should turn up ~4 more debris disks. Our estimates for where the dust resides in these disk systems is crude, with typical errors on the distance between the stars and the dust of about one order of magnitude. We also propose to obtain IRS 7-38um spectra of 15 of the systems known to have excesses, and use the spectra to improve these uncertainties significantly. By modeling the shape of the emission spectrum, we will accurately locate the inner-edges of the disks. For circumbinary disks, the location of the inner-edge will provide tests of models for dynamical stability (of the dust parent bodies), and possibly provide evidence of planets on circumbinary orbits (if the inner-edge turns out to be well outside the region where it would be expected to be stable). For circumstellar disks, the location of the inner-edge may be diagnostic of the presence of planets on circumstellar orbits, if it is found to be well-removed from the star.

Spitzer Space Telescope - General Observer Proposal #20734

Spitzer Imaging and Spectroscopy of a Newly Resolved Debris Disk

Principal Investigator: Karl Stapelfeldt
Institution: Jet Propulsion Laboratory

Technical Contact: Karl Stapelfeldt, Jet Propulsion Laboratory

Co-Investigators:
Chas Beichman, Michelson Science Center, Caltech
Geoff Bryden, Jet Propulsion Laboratory

Science Category: circumstellar/debris disks
Observing Modes: IracMap IrsStare MipsPhot MipsSed
Hours Approved: 4.8

Abstract:
Spitzer photometric surveys are currently being conducted for new debris disks in the solar neighborhood. One of these studies, "The SIM/TPF Sample: First Steps in the Comparative Planetology of Neighboring Solar Systems", has detected 70 micron excess from the G0 star HD 48682 (56 Aurigae; d= 17 pc). This detection is particularly significant because it appears to be the first debris disk that has been spatially resolved with Spitzer/MIPS beyond the "Fabulous Four" disks of beta Pic, Fomalhaut, Vega, and epsilon Eridani. We propose 4.8 hours of follow-up Spitzer observations to better resolve the disk, fully characterize its spectral energy distribution, and search for any companion objects. Our goals are to understand the disk density distribution and dust properties, placing this system in context with other nearby stars with dusty debris.

Spitzer Space Telescope - Archive Research Proposal #20759

The Angular Momentum Evolution of Young, Low-Mass Stars: Probing Magnetic Star-Disk Coupling Through Modeling and Analysis of Circumstellar Disk Structure

Principal Investigator: Keivan Stassun
Institution: Vanderbilt University

Technical Contact: Keivan Stassun, Vanderbilt University

Co-Investigators:
Eric Jensen, Swarthmore College
Thompson LeBlanc, Fisk University
Luisa Rebull, CalTech

Science Category: circumstellar/debris disks
Dollars Approved: 69062.0

Abstract:
The evolution of stellar angular momentum is a fundamental component of the star-formation process. Theory suggests that stellar magnetospheres couple to circumstellar disks, thereby regulating stellar angular velocities for the lifetimes of the disks. A key, testable prediction of the disk-locking hypothesis is that the stellar magnetosphere will clear out an inner hole in the circumstellar disk, with the inner edge of the disk being truncated at the distance from the star at which circumstellar material orbits the star at the stellar rotation period (the co-rotation radius). We propose here to test this prediction using Spitzer and HST archival data for a sample of more than 700 pre--main-sequence stars in Orion. Are the structures of circumstellar disks around young stars in fact correlated with the stars' rotation periods in the manner required by current theory for angular momentum regulation of the star by the disk? We propose to use archival IRAC and MIPS flux measurements together with optical and near-IR flux measurements from HST to test this hypothesis. These data, combined with measurements of stellar rotation period and spectral type from the literature, provide a dataset of unprecedented quality, size, and uniformity. The HST and IRAC data will detect the stellar photospheres of our sample stars (or excess emission if it is present) at wavelengths from 0.3 to 8 microns, while the MIPS data will provide sensitive constraints on the presence of cooler dust. These observations will be compared with sophisticated models of spectral energy distributions to test the hypothesis that these stars are coupled to disks whose inner regions are cleared by the magnetospheres in the manner predicted by theory. This proposal constitutes an integral part of a Ph.D. thesis project aimed at systematically investigating the relationship between the structure of circumstellar disks in the context of magnetospheric accretion, and current theories of pre-main-sequence stellar angular momentum evolution.

Spitzer Space Telescope - General Observer Proposal #30022

MIPS Observations of the 100 Myr old Blanco 1 Cluster: An Attempt to Determine the Frequency of Vega-Type Disks for a Coeval Population of Stars of Vega's Age

Principal Investigator: John Stauffer
Institution: Spitzer Science Center

Technical Contact: Luisa Rebull, SSC

Co-Investigators:
Steve Strom, NOAO
Luisa Rebull, SSC
David Barrado y Navascues, LAEFF, Spain
Scott Wolk, CXC/SAO
John Carpenter, Caltech
Giusi Micela, Palermo, Italy
Dana Backman, NASA Ames
Mike Meyer, University of Arizona

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 13.5

Abstract:
We propose to obtain MIPS photometry observations of 25 well-established members of the Blanco1 open cluster having spectral types from A0 through G0. Blanco1 is the only reasonably young (age < 150 Myr), reasonably nearby (distance < 250 pc) open cluster that is located both far from the ecliptic plane (beta = -28 degrees) and far from the galactic plane (b = -79 degrees!). It thus offers the best possibility to obtain MIPS photometry capable of detected debris disks at both 24 and 70 microns for a coeval population well beyond the PMS era. Previous Spitzer programs searching for debris disks in open clusters have only obtained good data at 24 microns; if approved, the Blanco 1 observations would be the first dataset capable of placing useful constraints on the incidence of Vega type disks (debris disks only showing excesses longwards of 24 microns) for a cluster whose age is similar to that of Vega and is of order the beginning portion of the era of maximum bombardment in our solar system.

Spitzer Space Telescope - General Observer Proposal #20058

Epsilon Aurigae: a Laboratory for Understanding Circumstellar Disk Physics

Principal Investigator: Robert Stencel
Institution: University of Denver

Technical Contact: Robert Stencel, University of Denver

Co-Investigators:
Dana Backman, SOFIA
Edward Guinan, Villanova University
Thomas Ake, Johns Hopkins University

Science Category: circumstellar/debris disks
Observing Modes: IrsStare MipsPhot MipsSed
Hours Approved: 2.2

Abstract:
Circumstellar disks are now known to be common around young stellar objects. However, their dimensions and compositions are measured only with difficulty. Models suffer from lack of key constraints. The disk around the secondary in the epsilon Aurigae binary, in contrast, has some well-determined properties. A disk is inferred from eclipse circumstances to be a 20 AU diameter, viewed edge-on & partially covers the F0 supergiant primary star for 2 full years during the 27 year binary period. This disk was discovered to be a strong thermal IR source during the 1982-84 eclipse, in part by IRAS. We seek IRS & MIPS SED data to clarify the nature and evolutionary status of this large protoplanetary-like disk & help to better constrain a class of disk models. This is among the most massive stellar systems with a disk. Its dimensions are well-known from the eclipse light curve. Temperature of the disk facing us during eclipse is known from its IR SED; the composition & velocities of gas from the secondary are known from absorption lines detected in the last eclipse. The mass of the system & proximity of the disk to the luminous primary star let us explore extremes of circumstellar disk physics. The secondary now is near quadrature, the time of most rapidly changing geometric aspect, so that measurements now give best resolution of temperature versus azimuth angle around the disk. Our goals include: More precisely defining temperature & projected size of the disk-shaped IR-emitting secondary object via IRS and MIPS measurements; Searching with IRS for emission and absorption features, against the cool secondary; Determining grain composition & properties via the full range of SST spectroscopy coverage [IRS & MIPS SED]; Seeking evidence for mass-loss history in extended material around the system [MIPS]; Establishing baselines of these & other measures for comparison during forthcoming eclipse campaigns (2009). It is only with SST that these science goals can be accomplished.

Spitzer Space Telescope - General Observer Proposal #3716

Accretion Outbursts in EXORs and their impact on the Circumstellar Environment

Principal Investigator: Guy Stringfellow
Institution: University of Colorado

Technical Contact: Guy Stringfellow, University of Colorado

Co-Investigators:
Peter Abraham, Konkoly Observatory
Agnes Kospal, Konkoly Observatory
Timo Prusti, European Space Agency
Fred Walter, State University of New York, Stony Brook

Science Category: circumstellar/debris disks
Observing Modes: IracMap IrsMap IrsStare MipsSed
Hours Approved: 20.0

Abstract:
EXORs, named after the prototype EX Lup, are a very small subclass of classical T Tauri stars (CTTSs) which experience rather major optical outbursts. Outbursts of the EXORs are intermediate between the long lived and more energetic FU Ori type outbursts (FUORs) and the more modest accretion variability of the CTTSs. EXORs undergo large amplitude outbursts as a direct result of enhanced mass accretion from their circumstellar disk. The accretional energy liberated results in a brightening of 3--5 magnitudes in the optical. The outbursts play a major role in modifying the circumstellar environment, and initiate the formation of winds, jets, and H-H objects, and dispersal of the disk. The large physical changes in the circumstellar environment during such outbursts likely influence the formation and evolution of giant planets and brown dwarfs. EXOR, and the related FUOR, outbursts frequently occur over the disk-accretion lifetime of young stellar objects. However, the characteristics of the EXORs are poorly understood due to the paucity of observational data during both quiescence and in outburst; the PI has ongoing ground-based programs in the optical and near-IR to rectify this. The (variable?) near-IR colors of the EXORs indicate a range of properties, some being optically thin while others are massive and optically thick. Exactly how the disk replenishes itself between outbursts and the underlying mechanism that triggers the outbursts remains a mystery. We propose to obtain the necessary SST data that will (1) determine the spectral energy distribution of the extended disk, (2) deduce the temperature distribution of the disk and it's composition, (3) determine how rapidly the disk is being replenished and how the temperature structure and composition respond to the infall of matter onto the disk, and (4) gain insight into the trigger mechanism of the outburst and how this affects the outer disk.

Spitzer Space Telescope - General Observer Proposal #20296

Deep 24 micron Imaging of Nearby Debris Disks around A Stars

Principal Investigator: Kate Su
Institution: The University of Arizona

Technical Contact: Kate Su, The University of Arizona

Co-Investigators:
George Rieke, University of Arizona
Christine Chen, NOAO
Michael Jura, UCLA

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 13.2

Abstract:
Although it is the prototypical debris disk, Spitzer observations of Vega show that its disk behaves in a very unexpected way. To low surface brightness, it has a diameter of 3.5 arcmin, about 1600 AU. We have modeled this disk and shown that the large size is due to small grains, of order 10 microns or even less, being ejected from the system by radiation pressure. The mass loss rate is so large that it is very unlikely that the current situation has persisted for the life of the star (about 350 million years). Instead, we believe that a major event within roughly the last million years, perhaps a collision involving an object of 1000 km diameter, has produced a huge cloud of very fine dust that is now being ejected from the system. We have found a second star, HD 69830, where a different train of logic arrives at a similar conclusion: a major event in the planetary system around the star during the past million years or so has produced large amounts of dust that are dominating the system's radiometric properties. These stars suggest a major shift in the way we model, or even think about, debris systems. It is probable that a significant fraction of them are dominated by the consequences of recent major events. To understand the prevalence of this behavior, we propose to obtain deep 24 micron imaging of 15 A stars with large excesses. These stars are selected to be close enough that we could detect Vega-like behavior; they are virtually the entire sample of A stars where such behavior can be detected with Spitzer. We will use theoretical tools developed on Vega to model the observations, either to explain the implications of any detected extended emission or to set robust upper limits to the rate of debris mass loss in systems that are point-like. Including Vega, beta Pic, and Fomalhaut (of which the first two have very extended debris) the total sample of 18 stars will provide a new picture of the behavior of exoplanetary systems.

Spitzer Space Telescope - Directors Discretionary Time Proposal #530

The structure of Debris Disk around 3-Planet Host Star HD218396

Principal Investigator: Kate Su
Institution: The University of Arizona

Technical Contact: Kate Su, The University of Arizona

Co-Investigators:
George Rieke, University of Arizona
Paul Smith, University of Arizona
Renu Malhotra, University of Arizona
Amaya Moro-Martin, CSIC
Geoffrey Bryden, Caltech/JPL

Science Category: circumstellar/debris disks
Observing Modes: IrsStare MipsPhot
Hours Approved: 1.5

Abstract:
Among more than 300 known debris disks, HD218396 (HR 8799) and Fomalhaut are the only debris systems that also harbor planets revealed by direct imaging. The Fomalhaut disk has been well explored by Spitzer given the proximity of the star; however, the disk around HD218396 is poorly studied. We propose to obtain MIPS 24, 70 and 160 micron images and a much deeper IRS spectrum to study the detailed structure of the disk around HD218396. The proposed data will help to better constrain the locations of dust belts. With these observations, we will gain a unique and important perspective on the influence of massive planets on debris disks. These measurements will also be crucial for the interpretation of the hundreds of known debris disks for which we do not have such detailed information on any accompanying planetary systems.

Spitzer Space Telescope - Theoretical Research Proposal #40380

Observational signatures of extrasolar Late Heavy Bombardments

Principal Investigator: Edward Thommes
Institution: Northwestern University

Technical Contact: Fred Rasio, Northwestern University

Co-Investigators:
Geoffrey Bryden, JPL

Science Category: circumstellar/debris disks
Dollars Approved: 86144.0

Abstract:
Spitzer observations have revealed hot dust around some Sun-like stars, at luminosities about three orders of magnitude higher than predicted by quasi-steady state disk evolution models. These findings have been interpreted as the signposts of a system-wide cataclysmic event analogous to the Late Heavy Bombardment (LHB) experienced by our own Solar System. At the same time, the frequency of detection of these events is consistent with ALL Solar-type stars passing through such a phase at some point in their lifetime. We propose to undertake an in-depth theoretical investigation of the ramifications of this intriguing result, which seems to be telling us something profound about the planet formation process---including how our own system fits into the picture. Using N-body simulations of planets embedded in planetesimal disks, and building on existing models, we intend to explore the pathways by which a planetary system can undergo a LHB-like event, and the different ways in which such events can play out. For each simulated system, we will calculate the dust generated by planetesimal collisions. In this way, we will generate a library of time-evolving dust distributions; these will allow us to make direct comparisons to existing Spitzer data, as well as testable predictions to guide future observations. Our results will be made available to the astronomy community via a series of papers to be published over the funding period.

Spitzer Space Telescope - Archive Research Proposal #20547

Meta Analysis on Debris Disks Surveys

Principal Investigator: David Tytler
Institution: University of California, San Diego

Technical Contact: David Tytler, University of California, San Diego

Co-Investigators:
David Kirkman, University of California, San Diego
Charles Beichman, CalTech
Geoffrey Bryden, JPL

Science Category: circumstellar/debris disks
Dollars Approved: 68362.0

Abstract:
We will conduct a comprehensive statistical appraisal of debris dust disks around normal stars. We will work with Spitzer MIPS 24 and 70 micron fluxes for 946 stars from 10 programs. For each star we compare the observed fluxes with those expected from a model stellar atmosphere. Approximately 15% of stars will show excess emission at 70 microns, from dust in debris disks 10 -- 100 AU from the stars. We will apply survival statistics to estimate the distribution of the number of stars with a given flux excess. We will estimate these distributions separately for stars of different spectral type, different metallicity and for those with and without planets. Survival statistics are ideal for this problem because they make full use of all the information in both the numerous upper limits and the occasional detections of excess flux. We will also sum MIPS images of various groups of 10 -- 100 stars of specific types. These sums average over the varying background which is a major source of error at 70 microns. For stars with low S/N detections or no detections of the stellar photospheres at 70 microns, the sums will promote non-detections into composite detections, with approximately 3 -- 10 times more sensitivity than individual images.

Spitzer Space Telescope - Directors Discretionary Time Proposal #287

Spitzer DDT observations of the anomalous X-ray pulsar 4U 0142+61

Principal Investigator: Zhongxiang Wang
Institution: McGill U.

Technical Contact: Zhongxiang Wang, McGill University

Co-Investigators:
Vicky Kaspi, McGill University
Cindy Tam, McGill University

Science Category: circumstellar/debris disks
Observing Modes: IracMap
Hours Approved: 2.0

Abstract:
Previous Spitzer/IRAC observations have discovered the mid-IR counterpart to anomalous X-ray pulsar (AXP) 4U 0142+61. The discovery may indicate the first detection of a fallback disk around a young, isolated neutron star. The putative disk likely formed from fallback material in the supernova explosion that produced the neutron star. The disk is likely bright in the mid-IR due to irradiation by the strong X-rays from the pulsar. At 10:04:19 UTC on 7 February 2007, the AXP exhibited a large fast-rise X-ray burst, with the peak X-ray flux being more than 100 times higher than its quiescent X-ray flux. Here we request Spitzer/IRAC observations of the source. Combining them with our scheduled Chandra ToO X-ray observations of the source, we will be able to test the disk model by searching for correlated mid-IR/X-ray flux changes. If correlated flux changes are found, the observations would allow us to further study the properties of the disk.

Spitzer Space Telescope - General Observer Proposal #30361

Protoplanetary Disks among X-ray Selected Young Stars in Cepheus B

Principal Investigator: Junfeng Wang
Institution: Pennsylvania State University

Technical Contact: Junfeng Wang, Pennsylvania State University

Co-Investigators:
Eric Feigelson, Penn State
Kevin Luhman, Penn State
Konstantin Getman, Penn State
Jeroen Bouwman, Max-Planck-Institut für Astronomie (MPIA)
Aurora Sicilia-Aguilar, MPIA
Hendrik Linz, MPIA
Warrick Lawson, University of New South Wales at ADFA

Science Category: circumstellar/debris disks
Observing Modes: IracMap
Hours Approved: 5.0

Abstract:
Because X-ray emission traces stellar magnetic activity, samples of pre-main sequence stars identified through X-ray emission are unbiased in terms of the presence of circumstellar disks. Using the Chandra X-ray Observatory, we have obtained a large sample of this kind for intermediate and solar-mass stars (0.4-8 solar masses) in the Cepheus B star-forming region. To measure the frequency of circumstellar disks as a function of mass in this cluster, and thus fully exploit the unbiased nature of our Chandra sample, we propose to obtain mid-IR photometry of these stars with the Infrared Array Camera aboard the Spitzer Space Telescope.

Spitzer Space Telescope - General Observer Proposal #40622

Search For Debris Disks Around A Few Radio Pulsars

Principal Investigator: Zhongxiang Wang
Institution: McGill University

Technical Contact: Zhongxiang Wang, McGill University

Co-Investigators:
Victoria Kaspi, McGill Univeristy
David Kaplan, MIT

Science Category: circumstellar/debris disks
Observing Modes: IracMap
Hours Approved: 4.1

Abstract:
We propose to observe 7 radio pulsars with Spitzer/IRAC at 4.5 and 8.0 microns, in an effort to probe the general existence of debris disks around isolated neutron stars. Such disks, probably formed from fallback or pushback material left over from supernova explosions, has been suggested to be associated with various phenomena seen in radio pulsars. Recently, new evidence for such a disk around an isolated young neutron star was found in Spitzer observations of an X-ray pulsar. If they exist, the disks could be illuminated by energy output from central pulsars and thus be generally detectable in the infrared by IRAC. We have selected 40 relatively young, energetic pulsars from the most recent pulsar catalogue as the preliminary targets for our ground-based near-IR imaging survey. Based on the results from the survey observations, 7 pulsars are further selected because of their relatively sparse field and estimated low extinction. Combined with our near-IR images, Spitzer/IRAC observations will allow us to unambiguously identify disks if they are detected at the source positions. This Spitzer observation program we propose here probably represents the best test we can do on the general existence of disks around radio pulsars.

Spitzer Space Telescope - Directors Discretionary Time Proposal #490

Possible Detection of A Dust Disk Around A Radio Pulsar

Principal Investigator: Zhongxiang Wang
Institution: McGill University

Technical Contact: Zhongxiang Wang, McGill University

Co-Investigators:
Victoria Kaspi, McGill University
David Kaplan, MIT

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 0.8

Abstract:
In our Spitzer/IRAC survey searching for debris disks around 7 relatively young, energetic radio pulsars, we find an object that is likely a counterpart to pulsar J0729-1448. The object had a flux of 80 micro-Jy at 8.0 microns and much deeper 4.5 and 2.2 (Ks band) micron flux upper limits (<10 micro-Jy), indicating its non-stellar origin. Based on studies of the pulsar, we suggest that the detection indicates the existence of a dust disk around the pulsar. If verified, this would be the first detection of a disk around a rotation-powered pulsar. In order to further study this object and verify our suggestion, we propose a 46 min MIPS 24 micron imaging observation. A detection or a deep flux upper limit from a non-detection would help our identification of the object, and if it is a disk, would allow us to set constraints on the properties, such as the size and temperature, of the disk. The observation, with a 5-sigma sensitivity of 75 micro-Jy at 24 microns, can only be made with Spitzer.

Spitzer Space Telescope - Theoretical Research Proposal #30040

Collisional Evolution of Circumstellar Debris Disks

Principal Investigator: Stuart Weidenschilling
Institution: Planetary Science Institute

Technical Contact: Stuart Weidenschilling, Planetary Science Institute

Co-Investigators:
Donald Davis, Planetary Science Institute
Pasquale Tricarico, Planetary Science Institute
John Stansberry, University of Arizona
Stephen Kortenkamp, Planetary Science Institute

Science Category: circumstellar/debris disks
Dollars Approved: 67828.0

Abstract:
A large number of circumstellar debris disks have been observed and characterized by Spitzer. The dust seen in these systems must be the product of collisions among larger parent bodies, which are not detected directly. We will constrain the properties of these bodies by collisional modeling, using a multi-zone code with realistic scaling of collisional outcomes. Dust production rates and depletion lifetimes will be computed for a selected set of debris disks having well-defined luminosities and radial extents, orbiting a variety of stellar types. The results will constrain the total mass of each disk and the sizes of the unseen parent bodies that are the source of the observed dust. The stochastic nature of the collisional code will allow us to estimate the likelihood that the observed dust abundance represents a steady state or a transient event due to a giant impact. The impact velocities (i.e., orbital eccentricities) required to match the observed dust production may allow us to infer the presence of planets in these systems.

Spitzer Space Telescope - General Observer Proposal #20227

An Amazingly Dusty Sun-like Star: Studying Cosmic Collisions at 1 AU

Principal Investigator: Alycia Weinberger
Institution: Carnegie Institution of Washington

Technical Contact: Alycia Weinberger, Carnegie Institution of Washington

Co-Investigators:
Inseok Song, Gemini Observatory
Ben Zuckerman, UCLA
Eric Becklin, UCLA

Science Category: circumstellar/debris disks
Observing Modes: IracMap IrsStare MipsPhot
Hours Approved: 3.6

Abstract:
We propose observations of an amazingly dusty Sun-like star of age a few hundred million years. The region in the vicinity of 1 AU from SAO 75016 is about one hundred thousand times dustier than the Zodiacal cloud of our solar system. The typical dust particle near HIP 8920 seems to be of micron size which is much smaller than typical Zodiacal dust particles. Survival times of these grains are only a few 1000 years, so this dust may be from frequent and/or huge collisions between asteroids or other ‘‘planetesimals.’’ HIP 8920 may be the extreme example of a small but growing number of very dusty, relatively old debris disks. We propose to study the composition and quantity of the dust around SAO 75016. We will determine whether this disk resembles the early Solar System during terrestrial planet formation. We will determine the mineralogical content and the radial distribution of its dust, including whether it also possesses Kuiper-belt region dust.

Spitzer Space Telescope - General Observer Proposal #30396

Examining Disk Dissipation in the Coeval HD 141569 Association Stars

Principal Investigator: Alycia Weinberger
Institution: Carnegie Institution of Washington

Technical Contact: Alycia Weinberger, Carnegie Institution of Washington

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 4.0

Abstract:
Stars are born with gas and dust rich circumstellar disks that contain the raw materials for planets. These disks dissipate quickly, after about 3 Myr, leaving whatever planets and remnant planetesimals managed to form. It has been difficult to study the transition; because it is so short, very few objects are known that have, say, cleared their inner disks but are still in the process of clearing their outer disks. I have identified 25 stars that formed along with the well known Herbig AeBe star HD 141569; I call these, albeit uncreatively, the HD 141569 Association. The eponymous star, at an age of about 5 Myr, is one of those few disks seen in transition. It has dust, but only cooler than about 300 K. It has gas, but at less abundance, relative to the dust, than the interstellar medium. The other members of the association now provide a means for studying disks at this important transition time. Does the dust dissipation timescale depend on stellar luminosity? Do lower mass stars have lower mass disks? We can begin to answer these questions by examining the HD 141569 Association members for disks; therefore I propose MIPS observations of these 25 stars.

Spitzer Space Telescope - General Observer Proposal #3577

MIPS Photometry of the HD 141569 Triple System: Resolving a Puzzle and Searching for Disks

Principal Investigator: Alycia Weinberger
Institution: Carnegie Institution of Washington

Technical Contact: Alycia Weinberger, Carnegie Institution of Washington

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 0.4

Abstract:
HD 141569A sports a dusty disk in the throes of transition from primordial proto-planetary disk to Beta Pictoris-like debris disk. As such stars are rare, it has been much studied and modeled. It also happens to be part of a 5 Myr old triple system with two M-type weak-line T Tauri star companions. Despite many studies over the last five years, the amount of mid-infrared emission from the disk around HD 141569A is unclear. Published ground-based 12 and 18 micron photometry disagree with each other and with IRAS results. I propose MIPS photometry of HD 141569 to help resolve the confusion over the flux density from this star and to look for small amounts of dust around the companions at 24 micron.

Spitzer Space Telescope - Directors Discretionary Time Proposal #278

Hi-Res Spectroscopy of New 15um Feature

Principal Investigator: Michael Werner
Institution: JPL

Technical Contact: Farisa Morales, JPL

Co-Investigators:
Farisa Morales, JPL
Michael Jura, UCLA

Science Category: Circumstellar/Debris Disks
Observing Modes: IrsStare
Hours Approved: 2.1

Abstract:
We request 2.1 hrs of DDT for hi-resolution observations of two stars. We have discovered previously unkown emission features near 15um in IRS Lo Resolution spectra of two bright stars - the A star Iota Cen (HD115892) and the carbon star HD100764. In HD115892, the 15um feature is accompanied by an extremely unusual continuum which is almost flat from 16 to at least 70um. In HD100764 the accompanying continuum is more blackbody-like with some PAH features, but there may be additional spectral features around 25um which are too bright to be measured reliably with Long-Lo. The appearance of th 15um features is suggestive of unresolved molecular bands. The proposed high resolution observations will resolve the bands, providing additional information to aid in identification. They will help us to understand if the same material is producing this feature in these two rather different stellar environments and indicate whether the features near 25um in HD100764 are real.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #102

A Search for Terrestrial Planetary Debris Systems and Other Planetary Debris Disks

Principal Investigator: Michael Werner
Institution: JPL

Technical Contact: Luisa Rebull, SSC

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 3.8

Abstract:
MIPS photometry will be obtained for a large sample of young, relatively nearby (generally within 100 pc) stars. The primary objectives of this program are: 1) identify systems possessing warm dust emission analogous to the zodiacal bands of the inner solar system, 2) find further examples of the pre-main-sequence planetary debris system (PDS) discovered for HD 98800B, and 3) identify Vega-type cooler dust excesses early in the evolution of their illuminating stars. This survey will constrain models of the origin and evolution of PDSs with the ultimate goal of determining how often, and in what circumstances terrestrial planets are formed. In addition, the survey will identify objects having mid-IR excesses that will be suitable targets for follow-up ground- and space-based observations at higher resolution. This program is a collaboration among four SIRTF GTOs (F. Low, M. Werner, M. Jura, and R. Gehrz). Each GTO will will submit his portion of the observational program separately.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #134

SWIRE Galactic Follow-up

Principal Investigator: Michael Werner
Institution: JPL

Technical Contact: Deborah Padgett, California Institute of Technology

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 8.2

Abstract:
We intend to perform SIRTF IRS short-low observations of interesting galactic sources discovered by the SWIRE photometric surveys. We expect our targets to fall into one of two categories. The first class is circumstellar debris disks, characterized by an excess of 24 and/or 70 micron emission over photospheric levels in a stellar source. The second is cool brown dwarfs, characterized by a deficit of 3.6 microns to 4.8 microns flux in a faint stellar source.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #135

2-MASS sources with 12um excesses

Principal Investigator: Michael Werner
Institution: JPL

Technical Contact: Sergio Fajardo-Acosta, Spitzer Science Center

Science Category: circumstellar/debris disks
Observing Modes: IracMap IrsStare MipsPhot
Hours Approved: 7.3

Abstract:
We will observe 14 main-sequence stars with 12 micron excesses, indicating the presence of warm (temperature of order 300 K) circumstellar dust debris disks. We discovered these systems using 2MASS J, H, Ks photometry, to estimate photospheric SEDs, and IRAS FSC or SSC 12 micron photometry. The dust is located at about 1--10 AU from the stars, in possible asteroidal clouds. We will obtain IRAC 3.6, 4.5, 5.8, and 8 micron very precise photometry (S/N > 100) to search for the hottest dust, and therefore the innermost edge, of the disks. Through IRS 5.3--21.8 micron spectroscopy (S/N > 20) we will search for PAH 6.2, 7.7, 8.6, and 11.3 micron features, and 10 and 20 micron silicate emission features. We will also search for colder dust, more distant from the stars, in Kuiper Belt-like regions, through MIPS 24 micron photometry (S/N > 20).

Spitzer Space Telescope - General Observer Proposal #20132

IRS Diagnostic Spectroscopy of Debris Disks

Principal Investigator: Michael Werner
Institution: JPL

Technical Contact: Michael Werner, JPL

Co-Investigators:
Geoffrey Bryden, JPL
Keith Grogan, JPL
Karl Stapelfeldt, JPL
Charles Beichman, Michelson Science Center
George Rieke, University of Arizona
Kate Su, University of Arizona
Christine Chen, NOAO
Michael Jura, UCLA
Scott Kenyon, Center for Astrophysics
Amaya Moro-Martin, Princeton
Sebastian Wolf, Heidelberg

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 45.3

Abstract:
We propose IRS low resolution spectroscopy of 89 late B and A stars with 24um excesses indicative of circumstellar planetary debris disks. These stars have 24um fluxes ranging from 1.2 to >4x the photosphere and estimated ages between <5 and ~600Myr. The excess as a function of age shows an overall decline but a range of excesses at each age. The availability of this sample affords us a unique opportunity to understand the temporal evolution of debris disks. In addition, we will study the structure and composition of the debris disks and search for evidence of associated planets. With this large sample of known disks we can also study correlationsof the disk properties with other properties of the stars, such as binarity and rotational velocity. Our team includes observers intimately familiar with MIPS and IRS data on debris disks as well as modelers and theorists who will support the interpretation of the observations.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #206

The Castor Moving Group

Principal Investigator: Michael Werner
Institution: JPL

Technical Contact: Christine Chen, NOAO

Science Category: circumstellar/debris disks
Observing Modes: IrsStare MipsPhot
Hours Approved: 2.7

Abstract:
We plan to search for 24, 70, and 160 micron excesses, using MIPS, around 8 main sequence stars in the Castor Moving Group. This association is believed to have an age of approximately 200 Myr and contains the well studied debris disk objects Fomalhaut and eps Eridani.

Spitzer Space Telescope - General Observer Proposal #30227

SWIRE Stars

Principal Investigator: Michael Werner
Institution: JPL

Technical Contact: Farisa Morales, JPL

Co-Investigators:
Deborah Padgett, IPAC/SSC
John Stauffer, IPAC/SSC
Farisa Morales, JPL

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 27.4

Abstract:
We propose IRS lo-res spectroscopy of 21 carefully selected stars from the SWIRE survey which show excess emission above the expected photospheric levels at 24um. This program differs from many extensive Spitzer stellar surveys, such as the FEPS legacy program and the MIPS GTO VLS survey in that the targets are not preselected. We hope through this approach to start to: 1) characterize the galactic population of stars with excesses at 24um; 2) to discover and identify rare transitional objects, such as protoplanetary nebulae; and 3) to test the inferences drawn from the targeted surveys. We will augment the Spitzer spectroscopy with 6.5 hrs. of visible spectroscopy from NOAO designed to permit classification of the stars. The type of program we undertake here exploits the unique discovery potential of the Spitzer mission.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #80

A Search for terrestrial Planetary Debris Systems and Other Planetary Debris Disks

Principal Investigator: Michael Werner
Institution: JPL

Technical Contact: Karl Stapelfeldt, Jet Propulsion Laboratory

Science Category: circumstellar/debris disks
Observing Modes: MipsPhot
Hours Approved: 15.0

Abstract:
MIPS photometry will be obtained for a large sample of young, relatively nearby (generally within 100 pc) stars. The primary objectives of this program are: 1) identify systems possessing warm dust emission analogous to the zodiacal bands of the inner solar system, 2) find further examples of the pre-main-sequence planetary debris system (PDS) discovered for HD 98800B, and 3) identify Vega-type cooler dust excesses early in the evolution of their illuminating stars. This survey will constrain models of the origin and evolution of PDSs with the ultimate goal of determining how often, and in what circumstances terrestrial planets are formed. In addition, the survey will identify objects having mid-IR excesses that will be suitable targets for follow-up ground- and space-based observations at higher resolution. This program is a collaboration among four SIRTF GTOs (F. Low, M. Werner, M. Jura, and R. Gehrz). Each GTO will will submit his portion of the observational program separately.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #90

The Fabulous Four Debris Disks

Principal Investigator: Michael Werner
Institution: JPL

Technical Contact: Karl Stapelfeldt, Jet Propulsion Laboratory

Science Category: circumstellar/debris disks
Observing Modes: IracMap IrsMap IrsStare MipsPhot MipsSed
Hours Approved: 46.9

Abstract:
This program is a comprehensive study of the four bright debris disks that were spatially resolved by IRAS: Beta Pictoris, Epsilon Eridani, Fomalhaut, and Vega. All SIRTF instruments and observing modes will be used. The program has three major objectives: (1) Study of the disk spatial structure from MIPS and IRAC imaging; (2) Study of the dust grain composition using the IRS and MIPS SED mode; and (3) companion searches using IRAC. The data from this program should lead to a detailed understanding of these four systems, and will provide a foundation for understanding all of the debris disks to be studied with SIRTF. Images and spectra will be compared with models for disk structure and dust properties. Dynamical features indicative of substellar companions' effects on the disks will be searched for. This program will require supporting observations of PSF stars, some of which have been included explicitly. In the majority of cases, the spectral observations require a preferred orientation to align the slits along the disk position angles. Detector saturation issues are still being worked for this program, and will lead to AOR modifications in subsequent submissions. The results from this program will be analyzed collaboratively by the IRAC, IRS, and MIPS teams and by general GTOs Jura and Werner.

Spitzer Space Telescope - General Observer Proposal #50501

The Ultimate Mid-Life Crisis: Active Accretion of Gas and Dust onto an Old Star

Principal Investigator: Ben Zuckerman
Institution: University of California, Los Angeles

Technical Contact: Ben Zuckerman, University of California, Los Angeles

Co-Investigators:
Carl Melis, UCLA
Inseok Song, SSC/Caltech
Joseph Rhee, UCLA

Science Category: circumstellar/debris disks
Observing Modes: IracMap IrsStare MipsPhot
Hours Approved: 0.5

Abstract:
We have discovered that TYC 4144 329 2 is an old, very dusty, rapidly accreting F3.5 star. We believe that this star and its associated gaseous and dusty disk represent an early stage in an evolutionary sequence of a newly identified class of stars. This class of stars is composed of old stars that engulf their short-period companions and, subsequently, go through a phase similar to the classical T Tauri phase of pre-main sequence evolution. In the present proposal we request IRS time to observe TYC 4144 329 2 to chart the evolution of the properties of dust particles in massive young disks around old stars.

Spitzer Space Telescope - General Observer Proposal #50549

The Spectacularly Dusty Fate of Short-Period Secondaries around Evolving Stars: Disk Evolution in the Aftermath

Principal Investigator: Ben Zuckerman
Institution: University of California, Los Angeles

Technical Contact: Ben Zuckerman, University of California, Los Angeles

Co-Investigators:
Carl Melis, UCLA
Inseok Song, SSC/Caltech
Joseph Rhee, UCLA

Science Category: circumstellar/debris disks
Observing Modes: IracMap IrsStare MipsPhot
Hours Approved: 0.5

Abstract:
We have discovered that TYC 596 145 1 is a lithium-rich, infrared excess, first-ascent red giant star. We believe that this giant star and its associated dusty disk represent a link in the evolutionary sequence of a newly identified class of stars. This class of stars is composed of old stars that engulf their short-period companions and, subsequently, go through a phase similar to the classical T Tauri phase of pre-main sequence evolution. In this proposal we request IRS time to observe TYC 596 145 1 to chart the evolution of dust particles in the massive young disks around old stars. Investigation of this giant's mid-infrared spectrum will also allow us an opportunity to probe the conditions under which organic material may form in situ in a disk environment, such as may have formed around our own young Sun. In particular, unlike organic material around young stars that may have been accreted directly from the interstellar medium during the star formation process, we can be confident that dust seen around TYC 596 145 formed directly from disk material.

Spitzer Space Telescope - General Observer Proposal #50180

Structure and composition of disks surrounding Herbig Be stars

Principal Investigator: Mario van den Ancker
Institution: European Southern Observatory

Technical Contact: Mario van den Ancker, European Southern Observatory

Co-Investigators:
Laurens Waters, University of Amsterdam, the Netherlands
Bram Acke, Institute for Astronomy, KULeuven, Belgium
Arjan Bik, European Southern Observatory, Garching, Germany
Xander Tielens, Kapteyn Institute, U Groningen, the Netherlands
Thomas Henning, MPIA, Heidelberg, Germany
Eric Pantin, CEA, Saclay, France
Roy van Boekel, MPIA, Heidelberg, Germany
Arjan Verhoeff, University of Amsterdam, the Netherlands
Jeroen Bouwman, MPIA, Heidelberg, Germany
Carsten Dominik, University of Amsterdam, the Netherlands
Kees Dullemond, MPIA, Heidelberg, Germany
Christoffel Waelkens, Institute for Astronomy, KULeuven, Belgium
Michiel Min, University of Amsterdam

Science Category: circumstellar/debris disks
Observing Modes: IrsStare
Hours Approved: 20.7

Abstract:
Infrared spectroscopy of proto-planetary disks using Spitzer IRS has in recent years provided a wealth of new insight into the physical and chemical processes that alter the warm dust located in the surface layers of these disks. Both grain growth and crystallization have been firmly established, and are interpreted as signposts of disk dissipation and possibly planet formation. One of the biggest surprizes of the Spitzer legacy so far is that very similar changes in grain properties occur over a wide range of central star mass (luminosity), from very low mass stars to Herbig Ae and late Be type stars. Grain processing thus does not seem to be related to central star properties, but is governed by the physical and chemical processes in the disk. Evidence is growing that also more massive stars may form through disk accretion and may have planets. We wish to establish the nature of the grains surrounding a carefully selected sample of massive Herbig Be stars in the 3-10 solar mass range, largely missed in all previous surveys. These observations will be an important addition to the spectral legacy of Spitzer. The data will allow us to establish up to which mass range grain processing occurs similar to lower mass young stars, and place disk processing and planet formation into the wider context of massive star formation.

Spitzer Space Telescope - General Observer Proposal #40369

Time Variable Accretion in White Dwarfs with Debris Disks

Principal Investigator: Ted von Hippel
Institution: University of Texas, Austin

Technical Contact: Ted von Hippel, University of Texas, Austin

Co-Investigators:
Bill Reach, IPAC
Fergal Mullally, University of Texas at Austin
Marc Kuchner, NASA Goddard
Mukremin Kilic, Ohio State University

Science Category: circumstellar/debris disks
Observing Modes: IracMap IrsStare
Hours Approved: 4.0

Abstract:
We propose to search for evolution in the flux from debris disks around white dwarf stars and to correlate that variability with ground-based measurements of changes in the accretion rates of metals onto the white dwarf photospheres. The contamination of WD photospheres with metals is an enduring puzzle because the extreme gravitational field of WDs should cause the denser metal atoms to sink on timescales as short as days. From recent ground-based and especially Spitzer observations, we now know of a handfull of WDs with debris disks, and we even know the size distribution and composition of the disk dust grains. The fact that the atmosphere of every WD with a debris disk is polluted by these metals means that the disks are almost certainly the source of the material. The disks themselves are thought to be created by tidally disrupted asteroids, comets, or other planetary bodies. Yet, at present, neither the accretion from the debris disk nor the formation of the disk is understood. Recently we have found compelling evidence for episodic accretion in the most studied WD of this class, G29-38. The photospheric Ca abundance varies by up to 70% and shows variations over periods as short as 15 days. We request 4 hours of Spitzer IRAC and IRS observations to monitor five debris disk WDs. These observations will compare the timescales and amplitudes of variations in the surface metal abundances (measured with simultaneous observations at Palomar, the Hobby Eberly Telescope, and Gemini) in these stars with the timing and degree of variability in mid-IR dust emission from the disks. Our measurements will be sensitive to the creation and accretion of micron and sub-micron grains, the time lag between dust creation in the disks and its accretion onto the stellar photospheres, indicating the dust source location(s), as well as temperature variations in the disks.

Spitzer Space Telescope - General Observer Proposal #20482

Measuring thermal emission of extrasolar giant planets with Spitzer

Principal Investigator: Eric Agol
Institution: University of Washington

Technical Contact: Eric Agol, University of Washington

Co-Investigators:
David Charbonneau, Harvard-Smithsonian Center for Astrophysics

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 20.8

Abstract:
We propose to detect three close-in extrasolar giant planets, 51 Peg b, HD 209458 b, and HD 179949b, by measuring the color variations between 3.6 and 8 microns with IRAC as a function of orbital phase. This will constitute the first photometric detection of thermal emission from non-transiting giant planets. We will calibrate the day-night temperature asymmetry with a light curve of the transiting planet HD 209458, allowing us to measure the inclination and masses of the non-transiting planets and pave the way for observations of many other extrasolar giant planets with Spitzer.

Spitzer Space Telescope - General Observer Proposal #40238

A search for Mars-mass extrasolar planets with Spitzer

Principal Investigator: Eric Agol
Institution: University of Washington

Technical Contact: Eric Agol, University of Washington

Co-Investigators:
David Charbonneau, Harvard University
Drake Deming, Goddard Space Flight Center
Jason Steffen, Fermilab
Heather Knutson, Harvard University
Nicolas Cowan, University of Washington

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 63.6

Abstract:
We propose to make 6 observations of the transits of the hot Jupiter planet HD 189733b and six observations of its secondary eclipse in order to detect variations of the times of transit/eclipse due to secondary planets in the system, if present. Spitzer is the best telescope for transit timing of this system, allowing nearly an order of magnitude better timing precision than HST or ground-based observations (for any transiting planet), as already demonstrated with prior Spitzer observations of this target. These observations will be sensitive to the presence of Mars-mass bodies in mean-motion resonance with the transiting planet. We will utilize the IRAC 8 micron camera as this has the best trade-off in stability and source brightness to allow for the highest timing precision. In addition we will constrain the eccentricity of the transiting planet and we will search for variations in the depth of the secondary eclipse which are predicted by models of weather on hot Jupiter planets.

Spitzer Space Telescope - Directors Discretionary Time Proposal #297

HAT-P-2B: A Direct Glimpse at the Stormiest Exoplanet

Principal Investigator: Gaspar Bakos
Institution: Harvard, CfA

Technical Contact: Gaspar Bakos, Harvard, CfA

Co-Investigators:
David Charbonneau, Harvard, CfA
Debra Fischer, San Francisco State U.
Matthew Holman, Harvard, CfA
Gregory Laughlin, UC Santa Cruz
Robert Noyes, Harvard, CfA
Dimitar Sasselov, Harvard, CfA

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 34.3

Abstract:
The HATNet project has just discovered an unusual transiting exoplanet (TEP), called HAT-P-2b (Bakos et al. 2007). This is the longest period (Porb = 5.63 days), by far the most massive (Mp = 8MJ), most eccentric (e = 0.5) and highest surface gravity (~ 149m s-2) TEP so far, and it orbits a bright (K = 7.6) F8 star. The high eccentricity means that the stellar distance during the orbit varies by a factor of 3, and the stellar insolation by a factor 9. Another consequence of the strongly varying angular orbital velocity is that the planet's spin period cannot be synchronized with its orbit period. Instead, tidal evolution will have brought it into spin-pseudo-synchronization in which it maintains approximate co-rotation at periastron (with spin period Prot ~ 1.96 days). The orientation of the orbit, with its major axis in the sky plane (omega ~ 180 deg) is very fortuitous. After the primary transit, the planet reaches periastron in only 13 hours, and gets occulted by the star in another 13 hours. At transit the insolation is ~1600 Solar Constants (SC's); it more than doubles to 3600 SC's at periastron, then drops back to 1600 SC's at secondary eclipse. The unique properties of this object, along with the chance orientation of the orbit, combined with large expected fluxes, make HAT-P-2b the stormiest exoplanet, and the best of its kind for weather study by Spitzer. We propose to take advantage of the fact that in just 34 hours - a small fraction of the total orbital period - we can use the huge thermal forcing to study the radiative response of the planetary atmosphere. Side-results will be precise determinations of the orbital eccentricity, longitude of periastron, and the planetary radius.

Spitzer Space Telescope - Theoretical Research Proposal #30175

Planetary Atmosphere Models for Spitzer Targets

Principal Investigator: Travis Barman
Institution: Uniiversity of California at Los Angeles

Technical Contact: Travis Barman, UCLA

Co-Investigators:
Bradley Hansen, University of California at Los Angeles

Science Category: extrasolar planets
Dollars Approved: 51164.0

Abstract:
Ground and space-based surveys have revealed a large and diverse population of planets orbiting a variety of hosts. Of these new planets roughly 20% have orbital semi-major axes less than 0.1 AU. Consequently, the stellar irradiation maintains the planetary temperatures at levels much higher than for isolated planets of similar age, opening up the possibility for direct detection. This proposal outlines steps toward improving our understanding of extrasolar planets by modeling their atmospheres and comparing these models to the growing number of Spitzer observations. Three important areas will be addressed: the degree of global energy redistribution, the impact of horizontal energy flow on the emergent spectrum and the measurement of atmospheric metal abundances.

Spitzer Space Telescope - General Observer Proposal #20523

Direct Study of Exoplanet Thermal Emission

Principal Investigator: David Charbonneau
Institution: Harvard

Technical Contact: David Charbonneau, Harvard

Co-Investigators:
Lori Allen, Smithsonian Astrophysical Observatory
Adam Burrows, University of Arizona
Thomas Megeath, Smithsonian Astrophysical Observatory
Guillermo Torres, Smithsonian Astrophysical Observatory

Science Category: extrasolar planets
Observing Modes: IRAC IracMap
Hours Approved: 19.8

Abstract:
We propose to observe two transiting exoplanet systems during predicted times of secondary eclipse, corresponding to the passage of the planet behind the star. This program builds on the success of our Director's Discretionary program, in which we demonstrated the use of Spitzer/IRAC as an ultra-precise spectrophotometer, and directly detected the thermal emission from an extrasolar planet. The primary observational product of the current proposal will be the flux measurement of the planetary emission for each planet in each of the 4 IRAC bands. These observations will truly inaugurate the era of remote sensing of extrasolar planets, and directly constrain models of the planetary atmospheres. Moreover, high-cadence observations of one system during ingress and egress will allow us to spatially resolve the planetary emission over the planetary surface, providing an unprecedented probe of the dynamics of these strongly irradiated exoplanet atmospheres.

Spitzer Space Telescope - Directors Discretionary Time Proposal #227

Taking the Temperature of the New Planet TrES-1

Principal Investigator: David Charbonneau
Institution: Harvard

Technical Contact: David Charbonneau, Harvard

Co-Investigators:
Lori Allen, Harvard-Smithsonian CfA
Timothy Brown, High Altitude Obs. NCAR
Ronald Gilliland, STScI
David Latham, Harvard-Smithsonian CfA
Georgi Mandushev, Lowell Obs.
Tom Megeath, Harvard-Smithsonian CfA
Guillermo Torres, Harvard-Smithsonian CfA
Roi Alonso Sobrino, Instituto de Astrofisica de Canarias
Francis O'Donovan, Caltech
Alessandro Sozzetti, Harvard-Smithsonian CfA

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 6.0

Abstract:
We propose to observe the newly-discovered transiting planet TrES-1 during the time of secondary eclipse (when the planet passes behind the star). A successful measurement of this eclipse would constitute the first direct detection of emission from an extrasolar planet. The secondary eclipse will reveal two key quantities of the planet: its temperature (from the eclipse depth), and its orbital eccentricity (from the eclipse timing). Moreover, these observations will enable us to characterize the high-precision, rapid-cadence photometric performance of IRAC. A successful demonstration of this innovative use of IRAC would open a new observing mode for Spitzer with applications extending well beyond the study of extrasolar planets.

Spitzer Space Telescope - Directors Discretionary Time Proposal #261

Thermal Emission from the Newest, Closest, and Brightest Transiting Planet

Principal Investigator: David Charbonneau
Institution: Harvard

Technical Contact: David Charbonneau, Harvard

Co-Investigators:
Lori Allen, SAO
Travis Barman, UCLA
Francois Bouchy, Astrophysical Laboratory of Marseille
Timothy Brown, High Altitude Obs. NCAR
Michel Mayor, Geneva Obs.
Tom Megeath, SAO
Claire Moutou, Astrophysical Laboratory of Marseille
Didier Queloz, Geneva Obs.
Stephane Udry, Geneva Obs.

Science Category: extrasolar planets
Observing Modes: IracMap MipsPhot
Hours Approved: 10.1

Abstract:
We propose to observe the newly-discovered transiting-planet system HD 189733 during two times of secondary eclipse, corresponding to the passage of the planet behind the star. Of the 4 known transiting planets accessible to Spitzer, this object offers by far the greatest signal-to-noise ratio, owing to both the apparent brightness of the system and the favorable ratio of the planetary flux to that of the star. By measuring the planetary flux in 5 band passes (3.6, 4.5, 5.8, 8.0, & 24 um), we will directly constrain models of the planetary emission, which in turn should allow identification of the molecules that dominate its spectrum. Moreover, high-cadence observations with IRAC during times of ingress and egress may permit us to spatially resolve the planetary emission over the surface of the planet, providing an unprecedented probe of the dynamics of these strongly irradiated exoplanet atmospheres. These observations will firmly establish Spitzer as the primary observatory in the nascent field of comparative exoplanetology.

Spitzer Space Telescope - General Observer Proposal #30825

HD 189733b: As The World Turns

Principal Investigator: David Charbonneau
Institution: Harvard

Technical Contact: David Charbonneau, Harvard

Co-Investigators:
Jonathan Fortney, NASA Ames Research Center
Adam Showman, University of Arizona
Curtis Cooper, University of Arizona
Lori Allen, Smithsonian Astrophysical Observatory
Thomas Megeath, Smithsonian Astrophysical Observatory
Heather Knutson, Harvard University
Eric Agol, University of Washington
Nicholas Cowan, University of Washington

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 33.0

Abstract:
We propose to monitor the closest and brightest transiting exoplanet system for a time of 33 hours, from just before the start of transit, to just after the end of secondary eclipse. Our primary science goal is the measurement of the planetary phase function, which is the modulation induced by the changing face of the planet as it orbits the parent star. Our secondary science goals are the ultra precise monitoring of the transit shape and the secondary eclipse curve. Our requisite photometric precision has already been demonstarted with recent observations, and we outline modest changes that will further increase the performance. Our proposed observations present an exciting opportunity to shed light, for the first time, on hot Jupiter weather patterns, and will extend the realm of planetary meteorology to other Solar systems. Specifically, our observations have the potential to determine (i) the day-night temperature difference, (ii) the temperature pattern, in particular whether the temperatures are swept eastward as predicted by recent theoretical modeling, and (iii) the directions of the km/s winds themselves. Observation of the longitudinal temperature structure will also inform debates about cloud patterns, disequilibrium chemistry, and the influence (if any) of atmospheric dynamics on long-term planetary evolution.

Spitzer Space Telescope - General Observer Proposal #40423

The Structure of the Lone Core-Dominated Exoplanet

Principal Investigator: David Charbonneau
Institution: Harvard University

Technical Contact: David Charbonneau, Harvard University

Co-Investigators:
Heather Knutson, Harvard University
Matthew Holman, Smithsonian Astrophysical Observatory
Joshua Winn, Massachusetts Institute of Technology
Eric Agol, University of Washington
Jonathan Fortney, NASA Ames Research Center
Ronald Gilliland, Space Telescope Science Institute

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 8.0

Abstract:
Of all the known transiting exoplanets, one is unique in that its large density implies the presence of a massive central core of heavy elements. Although this conclusion would seem to support the core-accretion theory of planet formation as opposed to coreless alternatives such as gravitational instability, the core is much larger than expected. Many theoretical investigations have attempted to explain why this planet did not accrete gas efficiently or, alternatively, how it lost much of its gas envelope at a later stage. Surprisingly, these conclusions hinge on an estimate of the planet radius that is only poorly determined by current standards. We propose to fix this problem by obtaining an ultra precise IRAC 8-micron light curve of a single planetary transit. We simulate the expected data and conduct a complete end-to-end analysis. We demonstrate that we will improve the estimate of the planetary radius to the level required to conclude beyond the shadow of a doubt that a massive core lies at the heart of this puzzling world.

Spitzer Space Telescope - Directors Discretionary Time Proposal #463

Solving the Mystery of the Largest Transiting Planet

Principal Investigator: David Charbonneau
Institution: Harvard University

Technical Contact: David Charbonneau, Harvard U.

Co-Investigators:
Adam Burrows, Univ of Arizona
Heather Knutson, Harvard Univ
Georgi Mandushev, Lowell Observatory
Francis O'Donovan, California Institute of Technology

Science Category: extrasolar planets
Observing Modes: IracMap IrsPeakupImage
Hours Approved: 24.0

Abstract:
We have just announced the discovery of TrES-4, which is by far the largest and least dense of the 22 known transiting explanets. The inflated radius is seriously at odds with published models of the physical structure of hot Jupiters, and is an extreme case within the general class of close-in gas giants with very low densities. We propose to determine the broadband spectrum of TrES-4 through precise photometry of the secondary eclipse at 3.6, 4.5, 5.8, 8.0, and 16 microns. These observations will permit a direct test of our team's recent discovery that close-in planets with inflated radii may have atmospheric temperature inversions whereas their non-inflated counterparts do not. If confirmed, this correlation could hold the key to finally unraveling the mystery of the large diversity in the radii of the hot Jupiter exoplanets. We will also confirm or exclude the alternate explanation that the planet is heated through ongoing dissipation of residual orbital eccentricity.

Spitzer Space Telescope - General Observer Proposal #50747

As the World Turns: Discrete Observations of a Pseudo-Synchronized Eccentric Transiting Planet

Principal Investigator: Bryce Croll
Institution: University of Toronto

Technical Contact: Bryce Croll, University of Toronto

Co-Investigators:
David Lafreniere, University of Toronto
Ray Jayawardhana, University of Toronto
Jonathan Langton, University of California at Santa Cruz
Gregory Laughlin, UCO/Lick Observatory
Norman Murray, Canadian Institute of Theoretical Astrophysics

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 30.0

Abstract:
We propose to obtain precise IRAC 8-micron observations of the eccentric transiting exoplanet HD 17156 b over three planetary spin periods. This newly discovered transiting system is notable because (a) it experiences a 26-fold increase in stellar insolation over its swing-in from apastron to periastron, and (b) it is expected that tidal evolution has brought it in pseudo-synchronization, with a resulting spin period of ~3.8d. This means that a single face of the planet will be flash heated near periastron by an intense blast of stellar irradiation that exceeds a 1000 times the solar flux at Earth. The timescales for radiative cooling and advective transport of energy to the other hemisphere after periastron passage have not yet been measured observationally, and are a source of significant uncertainty in theoretical models. Our proposed 8-micron observations will finely sample temperature variations over one spin period of the planet near periastron, and coarsely sample them over the preceding and following spin periods. To achieve the best possible photometric precision, and approach the photon noise limit, we will simultaneously observe (in full-array mode) a nearby reference star of similar magnitude, thus minimizing systematic effects. Our observations are timely as they require the unique high-precision mid-infrared capabilities of a cryogenic Spitzer. These observations will allow us to determine the radiative and advective timescales of this massive, gaseous exoplanet. An observational constraint on these timescales for this planet will considerably advance our understanding of the atmospheres of both eccentric gaseous and conventional hot Jupiters.

Spitzer Space Telescope - Directors Discretionary Time Proposal #258

Infrared Photometry of the Hot Earth Orbiting Gliese 876

Principal Investigator: Drake Deming
Institution: NASA's Godddard Space Flight Center

Technical Contact: Sara Seager, Carnegie Institute of Washington

Co-Investigators:
Sara Seager, Carnegie DTM

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 8.6

Abstract:
Rivera et al. (2005) have recently reported Doppler detection of a ~7.5 Earth-mass planet orbiting the nearby M-dwarf Gliese 876 with a period of 1.97 days. We propose to detect the phase variation of the IR thermal emission of this planet, using IRAC at 8 and 4.5 microns. Because this system lies only 4.7 pc from Earth, the IR flux from this terrestial planet is likely to be comparable to the thermal fluxes from the hot Jupter planets already detected by Spitzer. Since the planet's rotation is likely to be synchronous with its orbit, the amplitude and relative phase of the thermal emission curve will yield significant information on the existence and nature of an atmosphere on this extrasolar Earth. Our error level will be a factor of 8 below the maximum expected signal, and even a null result will be of significant interest.

Spitzer Space Telescope - Directors Discretionary Time Proposal #260

Infrared Photometry of the Very Hot Jupiter Orbiting HD 189733

Principal Investigator: Drake Deming
Institution: NASA's Godddard Space Flight Center

Technical Contact: Drake Deming, NASA's Godddard Space Flight Center

Co-Investigators:
Sara Seager, Carnegie DTM
Joseph Harrington, Cornell U.
L.Jeremy Richardson, Goddard Space Flight Center

Science Category: extrasolar planets
Observing Modes: IrsPeakupImage
Hours Approved: 6.0

Abstract:
The recently announced transiting extrasolar planet orbiting HD 189733 is a very hot Jupiter with an orbital period of only 2.2 days. It is not only the brightest representative of this dynamical class of extrasolar planets, it is the brightest of all known transiting extrasolar planets in the infrared. By comparing HD 189733b to members of the hot Jupiter class with somewhat longer orbital periods, Spitzer observations can provide true comparative exoplanetology. This will ultimately allow new insights and raise new questions - into the effect of initial mass on the planet's spectrum, on how it evolves in the presence of stellar irradiation, and on the physical origin of different dynamical classes of close-in giant planets. We propose to measure the planet's brightness temperature at 16 microns, by detecting the secondary eclipse to very high S/N, using IRS peak-up imaging photometry. Our observations will measure the planet's brightness temperature to a precision of ±13K, an order of magnitude more precise than our MIPS measurement of HD 209458b. Achieving this precision will enable the best possible suite of detailed follow-up studies (e.g., spectroscopy) to be planned for GO-3.

Spitzer Space Telescope - General Observer Proposal #30498

Spitzer Characterization of Super Earths

Principal Investigator: Drake Deming
Institution: NASA's Godddard Space Flight Center

Technical Contact: Sara Seager, Carnegie Institute of Washington

Co-Investigators:
Sara Seager, Carnegie Institution of Washington

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 12.0

Abstract:
We propose to characterize super-Earth-mass planets around nearby and infrared bright low-mass stars. We define super Earths to be planets between 5 and 30 Earth masses (and to include Neptune-mass planets). It may seem counter-intuitive that super Earths can be studied with Spitzer. However, the small size of M-dwarfs and the IR brightness of nearby M-dwarfs compensates for the small planetary radius of low-mass planets. We propose two related components in this program: (1) A search for infrared photometric orbital variation of the 7.5 Earth mass planet Gliese 876d in IRAC 4.5 and 8 micron bands. This will allow us to identify the presence or absence of a thick atmosphere. (2) Target of Opportunity observations of primary eclipse (transit) and secondary eclipse(s) of any hot super Earths to be discovered transiting M-dwarf stars. The primary eclipse (at IRAC 8 micron band) will allow a planet radius to be determined to 10% accuracy, enough to infer the planet's bulk composition (e.g., substantial gas envelope, liquid ocean interior, predominantly rocky or massive iron core, etc.). The secondary eclipse observations (in all four IRAC bands) will allow investigation of atmospheric escape, and planetary atmosphere composition and temperature.

Spitzer Space Telescope - General Observer Proposal #40466

Spectroscopy of the Exoplanet HD 209458b

Principal Investigator: Drake Deming
Institution: NASA's Goddard Space Flight Center

Technical Contact: Drake Deming, NASA's Goddard Space Flight Center

Co-Investigators:
Sara Seager, MIT
Joseph Harrington, Univ. Central Florida
Carey Lisse, Johns Hopkins Applied Physics Laboratory
Jeremy Richardson, American Astronomical Society

Science Category: extrasolar planets
Observing Modes: IrsStare
Hours Approved: 28.4

Abstract:
The spectra of two extrasolar planets (HD 209458b, and HD 189733b) have recently been measured using Spitzer/IRS at 7 -14 microns. Both planets show a lack of the water absorption that is expected to shape the IR spectra of these hot Jupiters. We propose follow-up observations of HD 209458b at 5 - 8 microns (SL2 mode) to measure the large gradient in planetary flux that we know (from IRAC) occurs over this wavelength range. Our observations will discriminate between models wherein water is depleted chemically, versus masked by cloud opacity, and will also provide information on the temperature gradient in the planet's atmosphere. We also propose to repeat our 7 -14 micron spectroscopy of HD 209458b, where we detected an emission peak in the planet's spectrum at 9.7 microns. We identified this peak as due to silicate clouds. Our repeat observations will use an improved technique, as recently developed by Grillmair et al. for HD 189733b, which will allow us to better determine the details of the silicate cloud composition.

Spitzer Space Telescope - General Observer Proposal #50440

Thermal Emission from the Super-Earth Orbiting GJ 876

Principal Investigator: Drake Deming
Institution: NASA's Godddard Space Flight Center

Technical Contact: Drake Deming, NASA's Godddard Space Flight Center

Co-Investigators:
Sara Seager, MIT

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 32.9

Abstract:
GJ 876d is a 7.5 Earth mass non-transiting super-Earth orbiting at 0.025 AU from its M4V host star. This system is a very near neighbor of the Sun, at only 5 pc distant, so the thermal flux from the planet will be maximized. We propose to detect the orbital phase variation of 8 micron thermal emission from the super-Earth mass planet GJ 876d during ~ 70% of the planet's 1.97 day period orbit. Our observations will rely on high precision photometry at 8 microns, focusing exclusively on this crucial capability that will disappear with the depletion of Spitzer's cryogen. We will detect this planet if it is a bare rock, or has only a thin atmosphere, for all plausible sizes and albedos. We will use a novel technical strategy that will "pre-flash" the IRAC detector to eliminate the time dependence of detector response.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30136

A Search for Widely-Separated Low-Mass Companions Around Extra-Solar Planetary Systems

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Michael Schuster, Smithsonian Astrophysical Observatory

Co-Investigators:
Michael Schuster, Smithsonian Astrophysical Observatory
Brian Patten, Smithsonian Astrophysical Observatory
Massimo Marengo, Smithsonian Astrophysical Observatory
Joseph Hora, Smithsonian Astrophysical Observatory
Kevin Luhman, Penn State University
Joseph Carson, Jet Propulsion Laboratory, Caltech
John Stauffer, Spitzer Science Center, Caltech
Patrick Lowrance, Spitzer Science Center, Caltech

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 9.4

Abstract:
We propose to extend our initial IRAC survey for widely-separated sub-stellar mass companions around extra-solar planetary systems in order to have a complete, volume-limited sample of Exoplanet systems within 50 pc of the Sun. Our survey is tuned to search for late-M, L, and T-dwarf companions in these systems that are located about 50 to 10,000 AU from the primary. These data, when combined with those from other ground-based surveys, will be used to answer important questions about the frequency of planetary and sub-stellar mass companions over a wide range of possible separations from their primaries. The combined Exoplanet companion search would offer an opportunity to place much stronger constraints on theoretical models of star and planet formation as well as giant planet migration.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30154

Observing Extrasolar Planets Transiting Bright Stars

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Lori Allen, Smithsonian Astrophysical Observatory

Co-Investigators:
Lori Allen, SAO
Massimo Marengo, SAO
Tom Megeath, Univ. Toledo
David Charbonneau, SAO
Mike Schuster, SAO
Adam Burrows, Univ. Arizona
Guillermo Torres, SAO

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 12.0

Abstract:
We propose to observe HD189733, a bright transiting exoplanet system during predicted times of secondary eclipse, corresponding to the passage of the planet behind the star. Having previously demonstrated the use of Spitzer/IRAC as an ultra-precise spectrophotometer, and directly detected the thermal emission from an extrasolar planet (Charbonneau et al. 2005; Deming et al. 2005), we seek to further extend IRAC's capabilities through application of an analysis technique for PSF-fitting of saturated stars. This technique allows high-precision flux measurements of bright stars saturated in the IRAC arrays. If successful, this project will pave the way for the observation of additional extrasolar planetary systems, once thought too bright for Spitzer. Applications to other types of sources are likely to follow. The advantage of this technique with respect to observing the eclipse using unsaturated frames taken in subarray mode is that fitting the PSF of a saturated star, spread over a larger number of pixels in the IRAC array, will provide better statistics in the signal and mitigate the effects of intra-pixel variations due to the undersampling of the IRAC PSF core.

Spitzer Space Telescope - Theoretical Research Proposal #50107

Exploring Hot Neptune Atmospheres

Principal Investigator: Jonathan Fortney
Institution: University of California, Santa Cruz

Technical Contact: Jonathan Fortney, University of California, Santa Cruz

Co-Investigators:
Mark Marley, NASA Ames Research Center
Didier Saumon, Los Alamos National Laboratory

Science Category: extrasolar planets
Dollars Approved: 125000.0

Abstract:
The first transiting "hot Neptune'' GJ 436b inhabits an entirely new region of phase space for extrasolar planetary atmospheres. This relatively cool, low-mass object should be the first transiting extrasolar planet to sport a methane-rich atmosphere. Like Uranus and Neptune it may also have an atmosphere highly enriched in heavy elements. Our experience with the complex atmospheres of the known hot-Jupiters has demonstrated that insights are best gained through the combination of Spitzer observations and atmospheric modeling . However, no models have investigated the atmospheres of Neptune-class exoplanets, which may well be super metal-enriched, and span a wider range in stellar insolation and atmospheric composition than we have previously encountered. GJ 436b the coldest transiting planet, is in entirely new irradiation and mass regimes and is also the target of a barrage of planned Spitzer observations. Here we propose a new generation of atmospheric modeling to understand Spitzer observations of this new planet and others like it.

Spitzer Space Telescope - Directors Discretionary Time Proposal #534

CoRoT-Exo-7b: Confirming the first transiting rocky planet

Principal Investigator: Francois Fressin
Institution: Harvard University

Technical Contact: Francois Fressin, Harvard University

Co-Investigators:
Suzanne Aigrain, University of Exeter
Malcolm Fridlund, European Space Agency
Tristan Guillot, OCA Nice
Heather Knutson, Harvard University
Tsevi Mazeh, Observatory of Tel-Aviv
Frederic Pont, University of Exeter
Heike Rauer, Berlin DLR
Guillermo Torres, Smithsonian Astrophysical Observatory
David Charbonneau, Harvard University

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 20.0

Abstract:
Earlier this month CoRoT announced the discovery of a periodic photometric signal compatible with a 1.76 REarth planet transiting a bright (V=11.7, K=9.8) K0V star. If confirmed, this planet would mark the beginning of a new era in exoplanetary science. Unlike Hot Jupiters, low mass planets may have a much larger variety of compositions, resembling anything from Earth analogs to mini-Neptunes. Transit observations allow us to estimate the planet's radius that is required to distinguish between these scenarios. In the past, transiting planet candidates have been confirmed by the detection of a radial velocity signal. Due to stellar activity, radial velocities from the HARPS spectrograph did not yield a clear measurement of the planetary mass. However the HARPS RVs do show a signal at the same period (0.853 days), compatible with a 2 to 9 Earth mass planet, although we can not entirely rule out an alternate scenario, in which the light curve results from the blended light of an eclipsing binary star system. The CoRoT team has pursued all possible ground-based follow-up observations, which have rejected most of these scenarios, and we have now reached the limits of what can be done with ground-based facilities. We propose to use Spitzer in channels 2 and 4 to rule out the few remaining cases. We show that the most likely remaining scenario would present an eclipse that is 2.5 times deeper in the Spitzer IRAC channel 2 than in the CoRoT bandpass. We propose to observe 4 transits of CoRoT-Exo-7 in order to obtain an independent detection at infrared wavelengths and to definitely rule out these blends scenarios. During the warm mission, Spitzer will carry out the same kinds of observations for Kepler candidates as part of program ES-60068. In fact CoRoT-Exo-7b (orbiting a bright K dwarf with a very short period) would be considered among the most promising for investigation if it were a Kepler target. The science case is so compelling and competitive that waiting for the next observability window in December 2009 could

Spitzer Space Telescope - Directors Discretionary Time Proposal #486

First atmospheric study of the young massive planet CoRoT-Exo-2b

Principal Investigator: Michael Gillon
Institution: Observatoire de Geneve

Technical Contact: Brice-Olivier Demory, Observatoire de Geneve

Co-Investigators:
Brice-Olivier Demory, Observatoire de Geneve
Jean Schneider, Observatoire de Paris
Joseph Harrington, U. Central Florida
Didier Queloz, Observatoire de Geneve
Magali Deleuil, OAMP

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 5.7

Abstract:
CoRoT-Exo-2b is the second transiting planet discovered by CoRoT, the first space transit survey. Compared to other transiting planets, CoRoT-Exo-2b is very peculiar. The 150 days long CoRoT photometric time series and the spectral analysis of the host star show that this G7 dwarf is still close to the ZAMS and is thus younger than 0.5 Gyr. With a planetary radius of 1.465 +/- 0.029 RJup, a mass of 3.31 +/- 0.16 MJup, the planet density is very close to the value for Jupiter. This is rather surprising because massive planets are supposed to get rapidly a radius comparable to Jupiter's. It is tempting to propose that the small density of CoRoT-Exo-2b is due to its very young age: this bloated planet would still be cooling. Unlike the 3 other known massive transiting planets, the very large stellar flux received by CoRoT-Exo-2b clearly puts it in the 'pM' class proposed by Fortney et al., and one should expect very deep IR secondary eclipses for this planet. We request 5.7 hrs to observe a secondary eclipse of CoRoT-Exo-2b with IRAC's simultaneously on 4.5 and 8um channels. Our observations will be an interesting test for the theory proposed by Fortney et al., and also a new important piece of information to understand the radius anomaly of bloated close-in planets. Its location in a mass-radius diagram and its youngness distinguish it clearly from other transiting planets and brings a unique opportunity to study the atmosphere of a massive planet in an early phase of its evolution.

Spitzer Space Telescope - Directors Discretionary Time Proposal #495

HD 40307b, the first transiting Super-Earth?

Principal Investigator: Michael Gillon
Institution: Observatoire de Geneve

Technical Contact: Michael Gillon, Observatoire de Geneve

Co-Investigators:
Christophe Lovis, Observatoire de Geneve
Michel Mayor, Observatoire de Geneve
Francesco Pepe, Observatoire de Geneve
Didier Queloz, Observatoire de Geneve
Stephane Udry, Observatoire de Geneve
Brice-Olivier Demory, Observatoire de Geneve
Drake Deming, NASA GSFC
Sara Seager, MIT

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 10.5

Abstract:
We stand on a great divide in the history of exoplanet discoveries. On the one side are the Spitzer observations of hot Jupiters that have revolutionized the burgeoning field of exoplanet characterization. On the other side are the Earth analogs with surface temperatures suitable for liquid water. Spitzer has a tremendous opportunity to bridge the divide by detecting the first transiting Super-Earth. HD 40307 is a bright (V=7.2, K=4.8) nearby (12.8 pc) K2 dwarf with three newly-discovered very low-mass exoplanets (Mayor et al., 2008). The innermost planet has a minimum mass of 4.21 M_Earth. With a 4.3 day period, the transit probability is 8% if the orbital plane is randomly aligned. We propose 10.5 h of IRAC-ch4 in subarray mode to monitor HD 40307 during the expected transit time. The first detection of a transiting Super-Earth would enable the first robust identification of a terrestrial-like exoplanet. With a measured radius and mass, the interior composition of the planet can be constrained. Spitzer is the only existing instrument able to perform this challenging detection. There is furthermore a compelling reason to conduct this particular search now, while Spitzer still has cryogen. This system is very favorable for observation (being only 12 pc distant), and a temperature measurement for the Super-Earth---by detection of the secondary eclipse---will be possible, once a transit is confirmed. Due to the nearly 40-degree orbital coverage we will obtain, our proposed observations will teach us about the presence and properties of the planet's atmosphere even if HD 40307b does not transit. We point out that in the case of a transit, the transit probability for the two other Super-Earths in the system is high. The possible payoff of our proposed 10.5 h program is thus extremely large.

Spitzer Space Telescope - General Observer Proposal #30473

A Spitzer Spectrum of the Transiting Exoplanet HD 189733b

Principal Investigator: Carl Grillmair
Institution: Spitzer Science Center

Technical Contact: Carl Grillmair, Spitzer Science Center

Co-Investigators:
David Charbonneau, Harvard University
Adam Burrows, University of Arizona
John Stauffer, Spitzer Science Center
Victoria Meadows, Spitzer Science Center
Lee Armus, Spitzer Science Center
Deborah Levine, Spitzer Science Center
Jeffrey van Cleve, Ball Aerospace

Science Category: extrasolar planets
Observing Modes: IrsMap
Hours Approved: 12.0

Abstract:
We propose to obtain a 7-15 micron IRS spectrum of the newly discovered, transiting extrasolar giant planet HD 189733b. The flux contrast is sufficiently high, and the parent star sufficiently nearby, that differential spectroscopy should yield a moderate signal-to-noise ratio spectrum in a relatively short amount of time. This would represent an enormous leap in our capabilities, ushering in a new era of detailed, quantitative spectral studies of nearby exoplanets.

Spitzer Space Telescope - General Observer Proposal #40504

A Spitzer/IRS Legacy Reference Spectrum for Exoplanet HD 189733b

Principal Investigator: Carl Grillmair
Institution: Spitzer Science Center

Technical Contact: Carl Grillmair, Spitzer Science Center

Co-Investigators:
David Charbonneau, Harvard-Smithsonian Center for Astrophysics
Adam Burrows, Steward Observatory
Kaspar von Braun, Infrared Processing and Analysis Center
Lee Armus, Spitzer Science Center
John Stauffer, Spitzer Science Center
Vikki Meadows, Spitzer Science Center
Jeffrey van Cleve, Ball Aerospace and Technologies Corporation
Deborah Levine, Spitzer Science Center

Science Category: extrasolar planets
Observing Modes: IrsMap
Hours Approved: 119.0

Abstract:
We propose to obtain high quality IRS spectra of HD 189733b, the nearest, brightest, and highest contrast transiting extrasolar planet known. Motivated by a fundamental disagreement between published models and Short-Low 7.5 - 14.7 micron spectra of HD 189733b and HD 209458b taken in Cycle 3, we propose to (1) extend wavelength coverage to 5.2 to 38 microns, and (2) increase the signal-to-noise ratio over that of existing spectra by a factor of three. The detection of spectral features, water absorption, or the degree of departure from blackbody behavior would allow us to discriminate among possible solutions to the current problem, and to put significant constraints on future models of hot Jovian atmospheres.

Spitzer Space Telescope - General Observer Proposal #50624

A detailed phase curve for upsilon Andromedae b

Principal Investigator: Bradley Hansen
Institution: UCLA

Technical Contact: Bradley Hansen, UCLA

Co-Investigators:
Joseph Harrington, University of Central Florida
Drake Deming, NASA Goddard Space Flight Center
Kristen Menou, Columbia University
Sara Seager, Massachusetts Institute of Technology
James Cho, Queen Mary University of London

Science Category: extrasolar planets
Observing Modes: MipsPhot
Hours Approved: 38.5

Abstract:
We propose an observation of the planet+star system upsilon Andromdae, with the aim of measuring an accurate phase curve for the closest planet in the system. Based on the radial velocity ephemeris and previous Spitzer pilot program, we tailor our program to address two principal scientific goals. The bulk of the observation consists of an extended observation to resolve and characterise the shape of the lightcurve near maximum brightness, with the goal of mapping the temperature distribution on the day-side face of the planet. In addition, we request several shorter exposures over the course of a single planetary orbital period, in order to accurately measure the amplitude of the phase variation and thereby constrain the day-night temperature contrast of the planet. Upsilon Andromedae b represents the archetype for a class of planet in which the high level of irradiation results in a hot day side and cold night side. This stands in contrast to another well characterised hot Jupiter system which seems to have little difference in day/night temperature contrast. By placing the archetypes of these two classes on an equal footing in terms of detail, our observations will help to elucidate and understand the difference in the two classes.

Spitzer Space Telescope - General Observer Proposal #30129

Target of Opportunity: New Observable Transiting Extrasolar Planets

Principal Investigator: Joseph Harrington
Institution: Cornell University

Technical Contact: Joseph Harrington, University of Central Florida

Co-Investigators:
Debra Fischer, San Fransisco State University
Drake Deming, NASA GSFC
L. Jeremy Richardson, NASA GSFC/NRC
Sara Seager, Carnegie Institution of Washington/DTM

Science Category: Extrasolar Planets
Observing Modes:
Hours Approved: 42.0

Abstract:
We propose a Legacy Target of Opportunity (TOO) program to observe transits and eclipses of new extrasolar planets. These measurements provide the most accurate planetary radii and the only emission fluxes possible with current telescopes for extrasolar planets; the next opportunity for the latter is with JWST. Radii and band fluxes constrain models of composition, chemistry, and atmospheric dynamics. They also provide the basic information needed for follow-on work. Since the spacecraft has a limited lifetime, rapid characterization is crucial. Transiting extrasolar planets are among the least anticipated and most productive targets for Spitzer. They are also among the most publicly stimulating. Five Discretionary Time proposals have been approved on this topic, and four have been accepted. Our goal is thus to bring this process into the TAC system while keeping these high-impact data public for everyone. We request 14 6-hour events, including 2 medium-impact TOOs. This is sufficient to cover all six accessible photometric bandpasses in eclipse and one event in transit for up to two planets. We anticipate that fewer will be used, based on discovery statistics. We provide quantitative criteria for activating TOOs. Our archival product will be calibrated lightcurves, to be submitted as electronic attachments with journal articles and archived with the Planetary Data System.

Spitzer Space Telescope - General Observer Proposal #40135

Intense Photometry of the Exotic Exoplanet HD 149026b

Principal Investigator: Joseph Harrington
Institution: University of Central Florida

Technical Contact: Joseph Harrington, University of Central Florida

Co-Investigators:
Drake Deming, NASA Goddard Space Flight Center
Sara Seager, Massachusetts Institute of Technology

Science Category: Extrasolar Planets
Observing Modes: IracMap IrsPeakupImage
Hours Approved: 57.0

Abstract:
Transiting planet HD 149026b is unique. Its mass and radius together indicate a heavy-element core of about 80 Earth masses, more than all the heavy elements in the solar system outside the sun. We made the first direct measurement of this planet in a Director's Discretionary Time (DDT) program, detecting a flux 0.00084 +- 0.00011 times that of its parent star. The corresponding brightness temperature is 2300 +- 200 K, making this the hottest of all measured planets. It is much hotter than the equillibrium temperature for zero albedo and uniform emission (1741 K). Even with instantaneous re-emission of all received stellar radiation, the planet needs zero albedo to achieve this temperature in a blackbody model. More realistic models predict lower planetary emission. Models with hot stratospheres emit enough, but we have not so far found one that is self-consistent. Our goals here are to obtain several secondary-eclipse measurements in all accessible bandpasses, which will provide S/N sufficient to distinguish among models, and to observe one transit at 8 microns. The latter is necessary because the area ratio with the star is unfavorable for ground-based transit radius measurements of sufficient accuracy to constrain models well. This measurement will be more accurate than is possible with any other telescope. The eclipses will test composition models of Fortney, Seager, and others, will test for variability, and will investigate an intriguing 1.7-sigma mismatch between the DDT eclipse timing and the best ground-based prediction. During our DDT analysis, we discovered and corrected several previously-unknown systematic errors, and established the optimum program for observing extrasolar planet transits with Spitzer. These will thus be the highest-accuracy measurements of this exotic planet until JWST.

Spitzer Space Telescope - General Observer Proposal #20605

16 and 24-Micron Photometry of Transiting Extrasolar Planets

Principal Investigator: Joseph Harrington
Institution: Cornell University

Technical Contact: Joseph Harrington, University of Central Florida

Co-Investigators:
Drake Deming, NASA GSFC
Jeremy Richardson, NRC/GSFC
Sara Seager, Carnegie Institution of Washington
James Cho, Carnegie Institution of Washington
Brad Hansen, University of California, Los Angeles
Kristen Menou, Columbia University

Science Category: extrasolar planets
Observing Modes: IrsPeakupImage MipsPhot
Hours Approved: 44.2

Abstract:
We have recently used Spitzer MIPS-24 to detect light from the transiting extrasolar planet HD 209458b during its secondary eclipse. Previously, there had been no direct detection of light from an extrasolar planet. Our calculated brightness temperature constrains models of this planet's thermal emission. We now propose additional eclipse photometry of HD 209458b using the IRS blue peak-up array and MIPS-24 to provide a brightness temperature at 16 microns, reduce the errors on our 24-micron measurement, search for variability due to atmospheric dynamics, investigate the puzzlingly large radius of this planet, and possibly derive the day/night temperature contrast. We also propose eclipse photometry of the second-brightest transiting planet, TrES-1b, in the IRS blue peak-up array, with similar goals. These pioneering measurements of extrasolar planetary fluxes will constrain the many competing radiative, chemical, and dynamical models of these planets' atmospheres.

Spitzer Space Telescope - Directors Discretionary Time Proposal #254

8-Micron Photometry of the "Hot Saturn" HD 149026b During Its Secondary Eclipse

Principal Investigator: Joseph Harrington
Institution: Cornell University

Technical Contact: Drake Deming, NASA's Godddard Space Flight Center

Co-Investigators:
Drake Deming, NASA's Goddard Space Flight Center
Jeremy Richardson, NASA's Goddard Space Flight Center
Sara Seager, Carnegie Institution of Washington, DTM
James Cho, Carnegie Institution of Washington, DTM
Bradley Hansen, UCLA
Kristen Menou, Columbia University

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 6.1

Abstract:
We will measure the flux of the newly-discovered extrasolar planet HD149026b in the 8-micron IRAC bandpass during its secondary eclipse. The observation lasts 6 hours. HD 149026b is a transiting "hot Saturn" planet that was announced on 1 July 2005 (Sato et al. 2005). The planet is unusual for its small size and high density. At 0.725 Rj and 0.36 Mj, it is 1.7 times as dense as Saturn. Models predict that it must have a heavy-element core of 67-78 Earth masses, and that the core should extend more than half the distance to the surface, not unlike Neptune's and Uranus's cores. This unusual composition could result in substantially different atmospheric minor constituents, albedo, chemistry, and dynamics from those of any other planet. It thus bears immediate study, both for its own sake and to provide the basic flux numbers needed to plan follow-on studies in GO Cycles 3, 4, and 5. We have demonstrated that we can analyze and publish such data very quickly: manuscript submission for our Spitzer MIPS-24 detection of HD 209458b during its secondary eclipse (Deming et al. 2005b) took under two months from the receipt of data, without the benefit of pre-existing similar analyses, such as we now have. There had previously been no direct detection of light from an extrasolar planet. These pioneering measurements of HD 149026b's fluxes will give us two fluxes temperatures and possibly an H_2O band depth. These will strongly constrain the many competing radiative, chemical, and dynamical models that are certain to appear in short order.

Spitzer Space Telescope - General Observer Proposal #40685

Target of Opportunity: New Transiting Exoplanets

Principal Investigator: Joseph Harrington
Institution: University of Central Florida

Technical Contact: Joseph Harrington, University of Central Florida

Co-Investigators:
Drake Deming, NASA Goddard Space Flight Center
Sara Seager, Massachusetts Institute of Technology
Debra Fischer, San Francisco State University
Peter Wheatley, University of Warwick
Gaspar Bakos, Hubble Fellow, Harvard-Smithsonian Center for Astr

Science Category: extrasolar planets
Observing Modes: IracMap IrsPeakupImage MipsPhot
Hours Approved: 60.0

Abstract:
We propose a Target of Opportunity (ToO) program to observe eclipses of new extrasolar planets. The measured band fluxes constrain models of composition, chemistry, and atmospheric dynamics. They also provide the basic information needed for follow-on work. Since the spacecraft is nearing the end of its limited lifetime, rapid characterization is crucial. Well below Spitzer's nominal sensitivity, these measurements are challenging, and optimized observing and analysis techniques that are not obvious are required to bring in the best signal. Many Discretionary Time proposals have been approved on this topic. Our goals, achieved with our Cycle-3 ToO program and continued here, are to ensure that each bandpass is observed for every planet with good predicted S/N, to obtain the best possible observations, to make these high-impact data public for everyone to use in planning followups, and to make the process of observing exoplanets smooth for observers and Spitzer by allocating a predictable number of events for the community through the TAC process. Based on actual discovery statistics and the known quantities of survey data in hand, we confidently predict about 22 new transiting-planet announcements in the coming year. Of these, one may be bright enough to measure in six bandpasses, and several may be marginal for Spitzer. We thus request 120 hours to cover about 18 6:40-hour eclipse events in low-impact ToOs. We provide quantitative criteria for activating ToOs. Our archival product will be calibrated lightcurves, to be submitted as electronic attachments with journal articles. Transiting extrasolar planets are among the least anticipated and most productive targets for Spitzer. They are also among the most publicly stimulating. These direct measurements provide the only emission fluxes possible with current telescopes for extrasolar planets, and stand as a Spitzer legacy for posterity. The next opportunity to observe them is with JWST.

Spitzer Space Telescope - Legacy General Observer Proposal #50517

New Transiting Exoplanets: Targets of Opportunity for Spitzer's Legacy

Principal Investigator: Joseph Harrington
Institution: University of Central Florida

Technical Contact: Joseph Harrington, University of Central Florida

Co-Investigators:
Drake Deming, NASA's Goddard Space Flight Center
Sara Seager, Massachusetts Institute of Technology
Kevin Stevenson, University of Central Florida
Nicolas Iro, NASA's Goddard Space Flight Center
Peter Wheatley, University of Warwick
Gaspar Bakos, Harvard Smithsonian Center for Astrophysics
Debra Fischer, San Francisco State University
Michael Gillon, Geneva Observatory
Gregory Laughlin, University of California, Santa Cruz

Science Category: extrasolar planets
Observing Modes: IracMap MipsPhot IrsPeakupImage
Hours Approved: 60.0

Abstract:
We propose a Target of Opportunity (ToO) program to observe photometric eclipses and transits of new extrasolar planets. The measurements constrain models of composition, chemistry, and atmospheric dynamics. We will populate a figure of predicted equillibrium vs. observed brightness temperature, which is starting to show a separate class of chemically-distinct planets. The events also inform follow-on work. As Spitzer's cryogen dwindles, rapid response is crucial. Well below Spitzer's nominal sensitivity, these measurements require optimized observing and analysis techniques. Our goals, begun with our Cycle-3 and -4 ToO programs and continued here, are to ensure that each bandpass is observed for every planet with good predicted S/N, to obtain the best possible observations, to make these high-impact data public for everyone to use in planning followups, and to make the process of observing exoplanets smooth for observers and Spitzer by allocating a predictable number of events for the community through the TAC process. Based on discovery statistics, 20-30 new transiting planets will be announced in 2008. Of these, 1-2 might be bright enough for six bandpasses, and many more will be observable in one or more IRAC bands. We thus request 120 hours to cover ~17 7:40-hour eclipse events in low-impact ToOs. This will cover 3-6 planets in all useful bands, depending on their brightnesses. We give criteria for activating ToOs, focusing on bright/unusual objects (eccentric, hot, cool, small, etc.). Our Legacy product is archivally-prepared calibrated lightcurves, submitted as electronic attachments with journal articles. Transiting extrasolar planets are among the least anticipated, most productive, and most publicly stimulating targets for Spitzer. These direct measurements provide the only emission fluxes possible with current telescopes for extrasolar planets, and stand as a Spitzer legacy for posterity. No comparable opportunity to observe exoplanets will be available until JWST.

Spitzer Space Telescope - Directors Discretionary Time Proposal #474

A New Approach for Finding Planets and Brown Dwarfs Around White Dwarfs

Principal Investigator: Mukremin Kilic
Institution: Ohio State University

Technical Contact: Mukremin Kilic, Ohio State

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 8.2

Abstract:
I propose to search for sub-stellar and planetary mass companions to low mass white dwarfs through direct imaging in the infrared. Recent discoveries of single low mass white dwarfs in the open cluster NGC 6791 and in the solar neighborhood imply that these low mass white dwarfs should form from metal-rich stars through extreme mass loss. Since 25% of the super-solar metallicity stars host gas giant planets, I expect a similar fraction of their descendants, single low mass white dwarfs, to have planetary mass companions as well. The results of this study will have a significant impact on understanding the evolution of planetary systems through the late stages of stellar evolution. Even the lack of any discoveries from our study will be important to show that single low mass white dwarfs actually exist in the Galaxy.

Spitzer Space Telescope - General Observer Proposal #40280

Portraits of Distant Worlds: Mapping the Atmospheres of Hot Jupiters

Principal Investigator: Heather Knutson
Institution: Harvard University

Technical Contact: Heather Knutson, Harvard University

Co-Investigators:
David Charbonneau, Harvard University
Lori Allen, Smithsonian Astrophysical Observatory
Jonathan Fortney, NASA Ames Research Center
Eric Agol, University of Washington
Nicolas Cowan, University of Washington
Adam Showman, University of Arizona
Curtis Cooper, University of Arizona

Science Category: extrasolar planets
Observing Modes: IracMap MipsPhot
Hours Approved: 138.0

Abstract:
Although Spitzer has made ground-breaking contributions to many areas of astronomy, its impact on the nascent field of exoplanetary science may be its single greatest legacy. In the few years since its launch, Spitzer has been responsible for the first detection of the light emitted by an extrasolar planet, the first spectrum of an extrasolar planet, and the first map of the flux distribution across the surface of an extrasolar planet. Spitzer's last full cycle of cryogenic observations represents a unique opportunity to cement this legacy for future generations with a set of observations that would directly address fundamental questions about the nature of extrasolar planets. We propose to map the brightness distributions on the surfaces of two extrasolar planets with significantly different properties in two widely separated wavelengths. This study would probe the three-dimensional structure of hot Jupiter atmospheres, and investigate the importance of irradiation, rotation rate, and surface gravity in determining the dynamic metrology of these atmospheres. Our recent detection of the day-night contrast for HD 189733b ("Mapping the Day-Night Contrast of an Extrasolar Planet", Knutson et al., Nature, submitted) has demonstrated that Spitzer is capable of making these ground-breaking observations; we seek to build on this success with a comparative study that will not be possible again until the launch of JWST. Our proposed observations consist of three parts: (1) mapping the day-night contrast of HD 189733b at 24 microns (33 hours), (2) mapping the day-night contrast of HD 209458b at 8 microns (52 hours) and (3) at 24 microns (52 hours), for a total of 138 hours of observations.

Spitzer Space Telescope - General Observer Proposal #50051

A Search for Water on a Neptune-Mass Transiting Planet

Principal Investigator: Heather Knutson
Institution: Harvard University

Technical Contact: Heather Knutson, Harvard University

Co-Investigators:
David Charbonneau, Harvard University
Drake Deming, NASA Goddard
Sara Seager, Massachusetts Institute of Technology
Eric Agol, University of Washington

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 33.0

Abstract:
GJ 436b is the only known Neptune-mass transiting exoplanet. Like Neptune, more than 80% of the mass is ice and rock, surrounded by a thin H/He envelope of only 1-3 earth masses. The similarities end there, however, as GJ 436b orbits a mere 0.03 A.U. from its M dwarf primary and has a toasty 700 K atmosphere. We propose to search for the signature of water absorption in this unusual planet's atmosphere by measuring the wavelength dependence of the transit depth in three IRAC bandpasses. From these observations we can constrain the abundance of water, and detect or exclude the presence of clouds and atmospheric hazes. Using the technique of transit timing, these observations will also allow us to search for additional planetary companions with masses as small as that of Mars. A second planet would provide a natural explanation for GJ 436b's ability to maintain a significant orbital eccentricity, despite the fact that the circularization time scale for this system is significantly shorter than its current age.

Spitzer Space Telescope - General Observer Proposal #50056

Mapping the Atmospheres of the Smallest Transiting Exoplanets

Principal Investigator: Heather Knutson
Institution: Harvard University

Technical Contact: Heather Knutson, Harvard University

Co-Investigators:
David Charbonneau, Harvard University
Jonathan Fortney, University of California, Santa Cruz
Adam Showman, University of Arizona
Eric Agol, University of Washington
Nicolas Cowan, University of Washington

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 110.0

Abstract:
Recent Spitzer observations of the phase variation of HD189733 have revolutionized our understanding of hot Jupiter atmospheres. By measuring the increase in the planet's brightness as its hot day side rotated into view, we were able to map the longitudinal temperature distribution and directly characterize the circulation in the atmosphere of this tidally-locked planet. This spatially-resolved information is significantly richer than secondary eclipse observations alone, which yield only a snapshot of the global properties of the dayside atmosphere. We propose to use our technique to map the atmospheres of the only known transiting Saturn-mass and Neptune-mass exoplanets. HD149026b and GJ436b are the smallest known transiting exoplanets, and as such they offer a unique opportunity to extend atmospheric circulation models to these smaller planets that are primarily ice and rock in composition. Such a data set would be invaluable in addressing questions about the properties of these metal-rich atmospheres, which are expected to differ significantly from those of the previously studied hot Jupiters. By gathering observations over a full orbit for GJ436b, we will study the effects of its significant orbital eccentricity on the properties of its atmosphere. These observations would be the first set to continuously span an entire orbit of an exoplanet. The light curve will allow us to distinguish between the variations in time caused by the planet's eccentric orbit and the expected spatial variations in temperature across the planet's atmosphere. Our observations of the very hot planet HD149026 will either confirm that heat redistribution is very inefficient in its atmosphere, or indicate a serious discrepancy in the global energy budget of this puzzling world.

Spitzer Space Telescope - General Observer Proposal #40386

The Big Swing: Observing the Periastron Passage of HD 80606b

Principal Investigator: Gregory Laughlin
Institution: University of California, Santa Cruz

Technical Contact: Gregory Laughlin, University of California, Santa Cruz

Co-Investigators:
Jonathan Langton, UC Santa Cruz
Drake Deming, NASA's GSFC

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 30.3

Abstract:
The extrasolar planet HD 80606b will pass within 7 stellar radii of its star at periastron passage on Nov 20, 2007. The event will last about 30 hours. At periastron the planet will be subject to irradiation over one hemisphere amounting to one thousand times the solar flux received at Earth. We have modeled the time dependent radiative response of the planet's atmosphere to this strong forcing, and we find that the response will be observable by Spitzer. IRAC observations at 4.5 and 8 microns will allow us to determine the radiative time constant in the planet's atmosphere, a crucial input needed for proper theoretical interpretation of many other Spitzer exoplanet results. We will observe this event using a continuous 30-hour sequence of observations in stellar mode.

Spitzer Space Telescope - General Observer Proposal #50734

IRAC Observations of Weather and Tidal Heating on Gliese 436 b

Principal Investigator: Gregory Laughlin
Institution: University of California, Santa Cruz

Technical Contact: Gregory Laughlin, University of California, Santa Cruz

Co-Investigators:
Jonathan Langton, UC Santa Cruz
Drake Deming, NASA's GSFC

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 32.7

Abstract:
We propose to use IRAC at 8 microns to observe eight successive secondary eclipses of the P=2.644d, Neptune-mass planet that transits the red dwarf star Gliese 436. Initial measurements of the Gliese 436b secondary transits suggested that the planet's high (e=0.15) eccentricity is generating signficant tidal luminosity. The eccentric orbit of the planet will lead to 83-percent variations in received flux over the course of half an orbit. Additionally, the planet will be rotating pseudo-synchronously, with a spin period P ~2.3 days that is significantly less than the orbital period. These factors will contribute to interesting global flow patterns on the planetary surface. Our hydrodynamical model predicts a sinusoidal time-dependent flux variation of amplitude 0.00012 and period ~ 3 days. By measuring the 8-micron flux at successive secondary transits, we will detect this oscillation, and obtain a data set that can be compared with both our model as well as models being developed by other workers in the field. In addition, our flux measurements can be averaged to obtain an improved estimate of the planet's tidal luminosity. This quantity allows us to derive a tidal quality factor, Q, which in turn gives important clues to the interior structure of this remarkable planet.

Spitzer Space Telescope - General Observer Proposal #30754

Search for Planetary Companions of epsilon Eridani and Fomalhaut

Principal Investigator: Massimo Marengo
Institution: Harvard-Smithsonian Center for Astrophysics

Technical Contact: Massimo Marengo, Harvard-CfA

Co-Investigators:
Karl Stapelfeldt, Jet Propulsion Laboratory
Michael Werner, Jet Propulsion Laboratory
Joseph Carson, Jet Propulsion Laboratory
Giovanni Fazio, Harvard-Smithsonian Center for Astrophysics
Thomas Megeath, Harvard-Smithsonian Center for Astrophysics
Michael Schuster, Harvard-Smithsonian Center for Astrophysics

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 17.2

Abstract:
Fifteen percent of bright main sequence stars possess dusty circumstellar debris disks revealed by far-infrared photometry. These disks are signposts of planetary systems: collisions among larger, unseen parent bodies maintain the observed dust populations against losses to radiation pressure and P-R drag. Images of debris disks at optical, infrared, and millimeter wavelengths have shown central holes, rings, radial gaps, warps, and azimuthal asymmetries which indicate the presence of planetary mass perturbers. Two important nearby examples are epsilon Eridani, where clumps in the submm ring suggest resonant trapping by a planet; and Fomalhaut, where the elliptical ring geometry requires planetary perturbations to maintain its apsidal alignment. With its unparalled sensitivity at 4.5 microns, Spitzer offers a major opportunity to directly detect planetary perturbers as small as a few Jupiter masses in these two nearby disk systems. Initial IRAC full-array imaging of these targets has demonstrated the PSF subtraction techniques needed to detect faint companions. However, bright star saturation artifacts prevented us from probing the region interior to the rings, which are 20 arcsec in radius. To extend the companion search inward to 5" radius, we propose IRAC subarray imaging of epsilon Eri and Fomalhaut. Our goal is to directly detect the giant planets perturbing the dust rings, and characterize them as CH4 dwarfs from their characteristic [3.6]-[4.5] color. Observations will be made at two epochs, to roll the telescope diffraction pattern across the sky as an aid to rejecting PSF artifacts. The results will be uniquely sensitive to cold, low-mass planets ("Y dwarfs") that are undetectable from the ground at optical and near-IR wavelengths. These observations represent perhaps the best opportunity to directly image extrasolar planets during the Spitzer mission.

Spitzer Space Telescope - General Observer Proposal #40976

IRAC Search for Planetary Mass Companions of Extrasolar Planetary Systems: Probing the Inner 400~AU

Principal Investigator: Massimo Marengo
Institution: Smithsonian Astrophysical Observatory

Technical Contact: Massimo Marengo, Harvard-CfA

Co-Investigators:
Karl Stapelfeldt, JPL/Caltech
Jason Wright, Univ. of Calfornia, Berkeley
Michael Schuster, Harvard-Smithsonian CfA
Joseph Carson, JPL/Caltech
Joseph Hora, Harvard-Smithsonian CfA
Kevin Luhman, Pennsylvania State University
Brian Patten, Harvard-Smithsonian CfA / NSF

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 15.1

Abstract:
The vast majority of extrasolar planetary systems have been found using the radial velocity method, which is currently limited to the detection of planets within ~ 5-10 AU from the central star. This is unfortunate because the presence of planetary mass bodies at the periphery of known extrasolar planetary systems wold have important implications for their evolution, explaining the high eccentricities observed in some systems, and enhanced collision rates responsible for the creation of debris disks. This proposal aims to fill this gap by searching for planetary mass bodies in the extrasolar planetary systems within 15 pc from the Sun within the field of view of IRAC subarray frames, at wavelengths that cannot be easily reached from the ground. The observations are designed to be sensitive to bodies with mass as low as 10 MJ at distances between 20 and 400 AU from the primary, complementing our previous search executed as part of the IRAC GTO time, focused on distances larger than 400 AU.

Spitzer Space Telescope - General Observer Proposal #30879

Thermal Emission from Extrasolar Planet XO-1

Principal Investigator: Peter McCullough
Institution: STScI

Technical Contact: Peter McCullough, STScI

Co-Investigators:
Jeff Valenti, STScI
Jeff Stys, STScI
Ronald Gilliland, STScI
Joseph Hora, CFA
Ken Janes, BU
Christopher Johns-Krull, Rice U

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 12.0

Abstract:
We propose 4-band IRAC observations of a newly discovered transiting planet with an orbital period of 3.9 days, which is longer than any other known planet transiting a bright star. We will compare Spitzer photometry obtained in and out of secondary eclipse to measure thermal emission from the planet and to constrain models of irradiated giant planets. In 12 hours of observation with IRAC, we will measure the effective temperature of the planetary atmosphere and constrain the orbital eccentricity. We recently discovered this Jupiter-sized companion in our XO transit search program, obtaining a transit depth of 2% and a transit duration of 2.5 hours. Our initial radial velocity follow up rules out companions greater than a few Jupiter masses. We request ToO status for this program with the expectation that the Spitzer observations will proceed once we definitively measure the radial velocity amplitude and hence the companion mass. Thermal emission from this newly discovered planet that transits a V=11 solar-type star should be easier to detect than emission from Tres-1b and HD 209458b. We will compare IRAC photometry with existing 4.5 and 8.0 um data for Tres-1 and use the 3.6 and 5.6 um data to test model predictions regarding water and CO opacity in the planet's atmosphere.

Spitzer Space Telescope - General Observer Proposal #40780

Secondary eclipses of XO planets

Principal Investigator: Peter McCullough
Institution: Space Telescope Science Institute

Technical Contact: Peter McCullough, Space Telescope Science Institute

Co-Investigators:
Christopher Burke, STScI
Jeff Valenti, STScI
Joseph Hora, CFA
Ken Janes, Boston University
Christopher Johns-Krull, Rice
Douglas Long, STScI

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 24.0

Abstract:
We propose to observe, in the 4 IRAC bands, the secondary eclipses of two newly discovered extrasolar transiting planets orbiting two bright stars. One star is notable for its high metallicity and being in a binary stellar system. The other star's planet is very massive, near the threshold for being a brown dwarf. We propose these as targets of opportunity, pending acceptance of refereed publications describing them.

Spitzer Space Telescope - Directors Discretionary Time Proposal #525

Thermal Inversion in the atmosphere of XO-3b

Principal Investigator: Peter McCullough
Institution: STScI

Technical Contact: Pavel Machalek, Johns Hopkins University

Co-Investigators:
Pavel Machalek, Johns Hopkins Univeristy
Christopher Burke, STScI
Christopher Johns-Krull, Rice University
Joseph Hora, Harvard University/CfA
Adam Burrows, Princeton University

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 13.8

Abstract:
We propose to observe the secondary eclipse of exoplanet XO-3b with all four IRAC bands in two 6.9 hour runs (13.8 hours total on target time) to detect thermal radiation from the planet and infer the presence of a thermal inversion in the planetary atmosphere. XO-3b is an unique planet with a high mass Mp = 12.5 MJup (Johns-Krull et al. 2008, Hebrard et al. 2008), which is close to the deuterium burning limit and so far has the highest observed surface gravity, g = 209 m.s^(-2) amongst the known transiting planets. Its orbit has eccentricity e = 0.287 +/- 0.005 (Hebrard et al. 2008), which causes stellar irradiance to vary three-fold over the entire orbit. The planet is further likely to revolve around the star on an almost polar orbit with a 70 deg +/- 15 deg inclination angle relative to the stellar equatorial plane (Hebrard et al. 2008). Of the 11 transiting planets with measured Rossitter-McLaughlin effect XO-3b is the only one with a nearly polar orbit, thus XO-3b represents a new orbital mode of transiting Hot Jupiters.

Spitzer Space Telescope - General Observer Proposal #50442

Hot Jupiters: Atmospheric Constraints from Repeated Eclipses

Principal Investigator: Kristen Menou
Institution: Columbia University

Technical Contact: Kristen Menou, Columbia University

Co-Investigators:
Emily Rauscher, Columbia University
Joseph Harrington, University of Central Florida
Drake Deming, NASA/GSFC
James Cho, University of London
Brad Hansen, UCLA
Sara Seager, MIT

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 30.7

Abstract:
We propose to perform repeated secondary eclipse measurements of the "hot Jupiter" planet HD 209458b, with IRAC at 8 micron. Tentative evidence for variability in eclipse depth exists for HD 209458b. This program will firmly establish the existence of variability (or constrain it extremely well), will provide some the most accurate brightness temperature measurements to date for any extrasolar planet and will achieve several important secondary goals. The data thus collected will constitute a long-lasting product in the form of constraints for existing and future generations of hot Jupiter atmospheric models.

Spitzer Space Telescope - General Observer Proposal #40255

Directly Detecting a Planet around a White Dwarf

Principal Investigator: Fergal Mullally
Institution: University of Texas, Austin

Technical Contact: Fergal Mullally, University of Texas, Austin

Co-Investigators:
Bill Reach, Caltech, Pasadena
Adam Burrows, University of Arizona
Marc Kuchner, Goddard Space Flight Centre

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 6.7

Abstract:
We propose to confirm the presence, and measure the mass, of the first planet discovered around a white dwarf. The planet was first detected as a periodic change in the observed arrival times of the stellar pulsations as it orbited the common center of mass of the system. The measured M sin(i) of the planet is 2 Jupiter masses and the orbital separation is 2.3 AU. We argue based on the pulsation properties of the star why we expect the orbit to be highly inclined and the true mass closer to 9 Jupiter masses. The low luminosity of the white dwarf makes it possible to directly detect the light from the planet as an excess flux in the 4.5um band of IRAC, providing an independent test of the existence of the planet. This is a new approach to direct detection and offers the first chance to test models of planetary atmospheres against objects analogous to our solar system. We describe in detail our efforts to minimize the systematic error in our observations and achieve a 1% photometric accuracy. With this sensitivity we will detect a planet with mass as low as 5 Jupiter masses with confidence of 3 sigma by comparing the magnitude of the excess to models.

Spitzer Space Telescope - General Observer Proposal #50140

Probing the Atmosphere of TrES-3, the Shortest Period Transiting Planet Within Spitzer's Reach

Principal Investigator: Francis O'Donovan
Institution: NASA Postdoctoral Program

Technical Contact: Francis O'Donovan, NASA Postdoctoral Program

Co-Investigators:
Adam Burrows, Princeton
David Charbonneau, Harvard University, Department of Astronomy
Drake Deming, NASA Goddard Space Flight Center
Heather Knutson, Harvard University, Department of Astronomy
Georgi Mandushev, Lowell Observatory

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 13.0

Abstract:
Our discovery of the transiting exoplanet TrES-3 presents an opportunity to study the atmosphere of a gas giant with an orbital period of only 31 hours, the shortest period of the known transiting exoplanets observable with Spitzer. The radius of TrES-3 is larger than permitted by current models of the structure of these highly irradiated short period gas giants. The key to understanding this large radius may lie in the composition of the planetary atmosphere, which dictates the planet's cooling after formation and hence its final radius. We propose to provide constraints for theoretical atmospheric models, by obtaining precision photometry of secondary eclipses of TrES-3 in the four Spitzer/IRAC bands. Our secondary eclipse observations will also permit ruling out a possible non-zero orbital eccentricity of the planet, another proposed cause of the bloated radius. TrES-3 has the largest potential reflected visible light signal of the known transiting gas giants that are observable with Spitzer. Before our proposed observations, the EPOCh mission will have measured this reflected optical light signal, and thereby placed constraints on the planetary visible spectra and hence atmospheric composition. TrES-3 will then be the only exoplanet with constraints on both its visible and infrared spectrum. Insights gained from reconciling these constraints with theoretical models will greatly improve our understanding of the inflated radii of TrES-3 and other exoplanets.

Spitzer Space Telescope - General Observer Proposal #20534

Measuring the Infrared Spectrum of the Transiting Extrasolar Planet HD 209458b

Principal Investigator: L. Jeremy Richardson
Institution: NRC/NASA Goddard

Technical Contact: L. Jeremy Richardson, NRC/NASA Goddard

Co-Investigators:
Drake Deming, NASA Goddard Space Flight Center
Joseph Harrington, Cornell University
Sara Seager, Carnegie Institution of Washington
Brad Hansen, UCLA
Kristen Menou, Columbia University
James Cho, Carnegie Institution of Washington

Science Category: extrasolar planets
Observing Modes: IrsStare
Hours Approved: 11.9

Abstract:
Researchers from two independent groups recently detected the first infrared signal from an extrasolar planet. Deming et. al. (2005a) detected the 24-micron flux density of HD 209458b using MIPS at secondary eclipse, and Charbonneau et. al. (2005) detected the infrared signal of TrES-1 using IRAC at 4.5 and 8 microns. These results have dramatically demonstrated the ability of Spitzer to characterize extrasolar planets. We propose to build on these observations with IRS spectroscopy of HD 209458b from 7.4 to 14.5 microns. By observing the system both during and outside of secondary eclipse, we will derive the planetary spectrum from the change in the shape of the continuum spectrum in combined light. These observations will lead directly to a measurement of the temperature gradient in the planetary atmosphere and the column density of water above the clouds, and we will search for variability due to atmospheric dynamics.

Spitzer Space Telescope - Theoretical Research Proposal #20366

Characterizing Hot Jupiter Transiting Extrasolar Planets with Spitzer Data

Principal Investigator: Sara Seager
Institution: Carnegie Institute of Washington

Technical Contact: Sara Seager, Carnegie Institute of Washington

Co-Investigators:
James Cho, Carnegie Institution of Washington
Brad Hansen, University of California at Los Angeles
Kristen Menou, Columbia University

Science Category: extrasolar planets
Dollars Approved: 55000.0

Abstract:
The field of extrasolar planet characterization has taken a dramatic step forward with the first direct detection of photons from an extrasolar planet by Spitzer. The flux decrement of the combined light of the planet and star was detected during secondary eclipse of the HD209458 system. Together with the measured stellar flux, this flux decrement gives a direct value for the planetary flux. The detection, made with MIPS at 24 microns, is at a wavelength several times longer than the expected peak of the planetary thermal emission (2 microns for a 1500K blackbody). Therefore, radiative transfer and atmospheric circulation models of the planetary atmosphere are essential to properly interpret this and other Spitzer measurements of extrasolar planets. This proposal aims to interpret Spitzer data in order to understand the atmospheres and physical characteristics of HD209458b and other hot Jupiter transiting extrasolar planets.

Spitzer Space Telescope - General Observer Proposal #3405

Characterizing the Atmosphere and Evolution of the Transiting Extrasolar Planet HD 209458b

Principal Investigator: Sara Seager
Institution: Carnegie Institute of Washington

Technical Contact: L. Jeremy Richardson, NRC/NASA Goddard

Co-Investigators:
Drake Deming, NASA Goddard Space Flight Center
L. Jeremy Richardson, NASA Goddard Space Flight Center
Joe Harrington, Cornell University
James Cho, Carnegie Institution of Washington
Brad Hansen, University of California, Los Angeles
Kristen Menou, Institut d'Astrophysique de Paris

Science Category: extrasolar planets
Observing Modes: MipsPhot
Hours Approved: 11.9

Abstract:
The Spitzer Space Telescope is the first astronomical facility in human history which has the capability to measure the effective temperatures of planets orbiting other stars via continnuum infrared radiation. There are currently two extrasolar planets which are known to transit their parent stars. Although Spitzer cannot spatially resolve these systems, for the brightest system Spitzer can exploit the transit geometry to isolate the infrared radiation of the planet to determine the planet's temperature. This capability of Spitzer is well known to the extrasolar planet community. We propose a small, focused observational program to measure key parameters for characterizing the transiting planet HD209458b's atmosphere and for understanding the planet's evolution---key parameters only measurable with the Spitzer Space Telescope. The parameters we will measure are: an effective temperature; a very accurate, dynamically-significant eccentricity for the planet's orbit; and an improved planetary radius at 40 times longer wavelength than currently measured. In addition, we will attempt to measure the temperature difference between the day and night sides of this tidally-locked planet.

Spitzer Space Telescope - Directors Discretionary Time Proposal #523

An Exoplanet Transmission Spectrum

Principal Investigator: Mark Swain
Institution: JPL

Technical Contact: Mark Swain, JPL

Co-Investigators:
Jerone Bouwman, MPIA
Gautam Vasisht,, JPL
Giovanna Tinetti, University College London
Carl Grillmair, SSC
Angelle Tanner, JPL

Science Category: extrasolar planets
Observing Modes: IrsMap IrsStare
Hours Approved: 10.1

Abstract:
We propose to determine the abundance of CO2 and HCN in the terminator region of the atmosphere of the hot-Jupiter exoplanet HD 189733b. This will be done by obtaining IRS spectroscopy measurements between 7.5 and 15 microns of primary eclipse event. Recent IRS secondary eclipse measurements (which probe the dayside region of the exoplanet atmosphere) have detected CO2 and HCN with abundances that cannot be due to equilibrium chemistry. This strongly implies that photochemistry is modifying the dayside atmospheric composition. By measuring the abundances of CO2 and HCN in the terminator region, we will determine if equilibrium chemistry dominates the atmospheric composition once the radiation forcing is removed. Additionally, our proposed measurements, when combined with existing near-IR and mid-IR spectroscopy data, will provide decisive constraints on the conditions, composition, and chemistry of an exoplanet atmosphere.

Spitzer Space Telescope - Directors Discretionary Time Proposal #461

Probing water vapor and CO in the atmosphere of HD 209458b

Principal Investigator: Giovanna Tinetti
Institution: University College London

Technical Contact: Sean Carey, SSC

Co-Investigators:
Jean-Philippe Beaulieu, IAP Paris
Alberto Noriega-Crespo, SSC
Mao-Chang Liang, Caltech/Academia Sinica
Yuk Yung, Caltech
Jonathan Tennyson, UCL
Bob Barber, UCL
Gilda Ballester, U. Arizona
David Sing, IAP Paris
Nicole Allard, IAP Paris
Ignasi Ribas, IEEC Barcelona
Franck Selsis, ENS Lyon

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 20.2

Abstract:
The success obtained with the 3.6, 5.8 and 8 um IRAC observations of HD 189733 leading to the discovery of the signature of water vapor in the atmosphere of the hot Jupiter HD 189733b, has prompted us to submit this DDT proposal. 13.4 hours are required for similar observations with the transiting Hot Jupiter HD 209458b: in particular we propose here to observe all the four IRAC bands and to search for water vapor and CO in the atmosphere of HD 209458b. The signal will be weaker than the one on HD 189733b but, according to our calculations, it will be detectable at 3 sigma in each band. HD 209458b is the gas giant with the lowest density and, because of its orbital parameters and stellar companion, it is warmer than HD 189733b. These characteristics guarantee that its atmosphere is very extended, hence it is an ideal target to be observed in primary transit. Despite the plethora of Spitzer observations of exoplanets, the ability to coadd different epochs of IRAC data to improve signal-to-noise in spite of systematics has not been demonstrated. We ask for an additional 6.7 hours (for a total of 20.2) for a second epoch observation of the transit at 3.6 and 5.8 um to beat the noise further down and provide better constraints on the temperature profile and water abundance.

Spitzer Space Telescope - General Observer Proposal #30590

CO and H2O absorptions in the atmosphere of the transiting planet HD189733b

Principal Investigator: Alfred Vidal-Madjar
Institution: IAP-CNRS

Technical Contact: Giovanna Tinetti, IAP-CNRS

Co-Investigators:
Giovanna Tinetti, IAP-CNRS
Francois Bouchy, OAMP
Jean-Michel Desert, IAP-CNRS
David Ehrenreich, IAP-CNRS
Roger Ferlet, IAP
Guillaume Hebrard, IAP-CNRS
Alain Lecavelier, IAP-CNRS

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 4.5

Abstract:
Water and carbon monoxide are predicted to be among the most abundant species in the atmosphere of Hot Jupiters. Here we propose to observe the signatures of these two crucial species in the atmosphere of the exoplanet transiting the bright star HD189733. The detection of the spectral signatures of H2O and CO will be performed in absorption during a primary transit observed in the four IRAC bands, at 3.6, 4.5, 5.8 and 8 microns. This method would sample long grazing lines of sights through the atmosphere at the two terminator limbs, in the 10^-2 to 10^-3 bar pressure range. Such a program is complementary to the exoplanet infrared emissions studies performed through secondary transits, as it allows the atmosphere to be probed at higher altitudes and lower pressure ranges, through simple absorption technic. From this observation we will be able to better constrain the planetary atmosphere models, their composition and possibly find the signature of planetary formation with various C/O ratios.

Spitzer Space Telescope - General Observer Proposal #40732

CO and H2O in the exoplanetary atmosphere of HD189733b (continued)

Principal Investigator: Alfred Vidal-Madjar
Institution: Institut d'Astrophysique de Paris

Technical Contact: Alain Lecavelier, Institut d'Astrophysique de Paris

Co-Investigators:
Giovanna Tinetti, Institut d'Astrophysique de Paris
Francois Bouchy, Institut d'Astrophysique de Paris
Jean-Michel Desert, Institut d'Astrophysique de Paris
David Ehrenreich, Institut d'Astrophysique de Paris
Roger Ferlet, Institut d'Astrophysique de Paris
Guillaume Hebrard, Institut d'Astrophysique de Paris
Alain Lecavelier, Institut d'Astrophysique de Paris
David Sing, Institut d'Astrophysique de Paris

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 9.0

Abstract:
Water and carbon monoxide are predicted to be among the most abundant species in the atmospheres of Hot-Jupiters. Here, we propose to observe the signatures of these two crucial species in the atmosphere of the exoplanet HD189733b, utilizing high signal-to-noise IRAC observations during primary transit of its bright parent star. In Cycle 3, we observed primary transits with IRAC at 3.6 and 5.8 microns, obtaining clear transit detections in the two bands. Analysis of this IRAC data has provided occultation depth measurements with high accuracy. As expected, the occultation depth is found to be larger at 5 microns, which can be attributed to the signature of water band absorption. However, following advice of Spitzer technical staff, in Cycle 3 we did not observe at 4.5 and 8 microns to avoid switching between the two stellar observation modes. Observations of these two additional channels will help confirm our atmospheric water detection and allow us to discriminate between competing absorbers. Additionally, the 3.6 micron observations are close to saturation and require additional observations to ensure non-linearity issues do not compromise our atmospheric detection. We propose new observations of two planetary transits to both confirm the results of Cycle 3 observations and to complement them by the search for CO absorption in the band at 4.5 microns. Because the transit time is short, the present program can be executed in only 9 hours of Spitzer time.

Spitzer Space Telescope - Directors Discretionary Time Proposal #282

Exploring the thermal emission of two new transiting planets from the WASP survey

Principal Investigator: Peter Wheatley
Institution: University of Warwick

Technical Contact: Peter Wheatley, University of Warwick

Co-Investigators:
Andrew Collier Cameron, St Andrews, UK
Stephane Udry, Geneva
Guillaume Hebrard, IAP
Will Clarkson, STScI
Frederic Pont, Geneva
Keith Horne, St Andrews, UK
Rachel Street, Queens-Belfast
Carole Haswell, The Open University, UK
Stephen Kane, Univ. of Florida
Andy Norton, The Open University, UK
Suzanne Aigrain, Cambridge, UK
Simon Hodgkin, Cambridge, UK
Leslie Hebb, St Andrews, UK
Don Pollacco, Belfast, UK

Science Category: Extrasolar Planets
Observing Modes: IracMap
Hours Approved: 11.6

Abstract:
We are shortly to announce the discovery of two transiting extra-solar planets from the Wide Angle Search for Planets (WASP) survey. One is expected to be the hottest of all hot Jupiters observable by Spitzer. The other may have suffered significant mass loss. Here we propose to use the unique capability of Spitzer to detect the thermal emission of both planets using secondary eclipse observations. We will measure their temperatures, and test planetary atmosphere models in a new high temperature regime. We will also search for modified molecular abundances that might result from mass loss. These observations will also inform the planning of a more comprehensive follow up programme of these important new planets in Cycle-4.

Spitzer Space Telescope - General Observer Proposal #50759

Searching for hot stratospheres of new transiting exoplanets from the WASP survey

Principal Investigator: Peter Wheatley
Institution: University of Warwick

Technical Contact: Peter Wheatley, University of Warwick

Co-Investigators:
Andrew Collier Cameron, University of St Andrews, UK
Brice-Olivier Demory, Observatoire de Geneve, Switzerland
Michael Gillon, Observatoire de Geneve, Switzerland
Joe Harrington, University of Central Florida
Carole Haswell, The Open University, UK
Coel Hellier, Keele University, UK
Don Pollacco, Queen's University Belfast, UK
Didier Queloz, Observatoire de Geneve, Switzerland

Science Category: extrasolar planets
Observing Modes: IracMap
Hours Approved: 19.3

Abstract:
We have recently discovered three new bright transiting explanets from the Wide Angle Search for Planets (WASP) transit survey. Here we propose to use the unique capability of Spitzer to detect the thermal emission of these planets during secondary eclipse. Together these new planets cover new regions of parameter space in terms of stellar irradation and surface gravity, and our primary goal is to test whether they exhibit stratospheric temperature inversions, as has been inferred for two other hot Jupiters. This will test the recent suggestion that there are distinct classes of hot Jupiters, with and without TiO and VO in the gas phase, and probe the atmospheric conditions at which the transitions between the two states occur.

Spitzer Space Telescope - General Observer Proposal #50667

Effective temperatures of the Three Coolest Brown Dwarfs.

Principal Investigator: Loic Albert
Institution: Canada-France-Hawaii Telescope

Technical Contact: Daniel Devost, Cornell University

Co-Investigators:
Xavier Delfosse, Grenoble University
Daniel Devost, Canada-France-Hawaii Telescope
Philippe Delorme, Grenoble University
Etienne Artigau, Gemini Observatory
Thierry Forveille, Universite de Grenoble.
Celine Reyle, Besancon
Thomas Roellig, NASA Ames
Sandy Leggett, Gemini Observatory
France Allard, Centre de Recherche Astronomique de Lyon

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap IrsStare
Hours Approved: 16.3

Abstract:
We propose to observe three ultra cool brown dwarfs with the IRS and IRAC that were found in the Canada-France Brown Dwarfs Survey. They were drawn from analysis of 550 square degrees of our ongoing survey from an initial pool of 920 i'-z' <= 1.7 red objects. The three brown dwarfs we propose to observe have a color z'-J as red or redder than the coolest known dwarf, ULAS0034, and a similar or brighter J-band magnitude. One of our candidates, CFBDS1, is already confirmed to be of spectral type T8.5+, and is slightly cooler than ULAS0034 (paper to be submitted). IRAC photometry combined to already available izYJHK data is an invaluable tool to reconstuct the SED and accurately determine the effective temperatures of these dwarfs. The IRS spectrum between 7 and 14 microns in turn will probe a temperature regime yet unexplored and constraint the currently uncertain atmosphere models. IRAC and IRS measurements of ULAS0034 and the 3 BDs we propose to observe here will provide unique templates to understand the many cooler dwarfs which will be discovered after the Spitzer coolant is depleted.

Spitzer Space Telescope - General Observer Proposal #3499

Mineralogy, Grain Growth and Dust Settling in Brown Dwarf Disks: Exploring the Conditions for Planet Formation

Principal Investigator: Daniel Apai
Institution: Steward Observatory/NASA Astrobiology Institute

Technical Contact: Daniel Apai, Steward Obs/NASA AI

Co-Investigators:
Antonella Natta, Arcetri Observatory, Italy
Jeroen Bouwman, Max Planck Institute for Astronomy, Heidelberg
Cornelius P. Dullemond, Max Planck Institute for Astrophysics, Garching
Nicole S. van der Bliek, AURA/CTIO
Ilaria Pascucci, Max Planck Institute for Astronomy, Heidelberg
Thomas Henning, Max Planck Institute for Astronomy, Heidelberg

Science Category: brown dwarfs/very low mass stars
Observing Modes: IrsStare
Hours Approved: 11.0

Abstract:
We propose to use 14.5 hours of SPITZER time to obtain the first low-resolution spectra of 19 selected brown dwarf (BD) disks. Building on the unique wavelength coverage and sensitivity of IRS we aim to study the conditions of planet formation in BD disks. The selected targets are of substellar nature, have known mid-infrared excess emission, and their brightness allows us to obtain high quality spectra. Recent spectroscopic studies demonstrated the remarkable similarity of the dust composition between primitive bodies of our Solar System, and many disks around low- and intermediate-mass stars at the planet-forming age. The major markers of the first steps of planet formation are the coagulation and growth of dust grains, the settling of large grains to the disk midplane influencing the disk structure, and the presence of processed dust, such as crystalline silicates. To identify these signatures in BD disks we adopt the following strategy: we will (1) use two-dimensional radiative transfer codes and model the spectral continuum aiming to determine the disk structure; (2) derive the dust composition and identify crystalline silicates and minor species by comparing synthetic dust spectra to the observations; (3) determine the grain size distribution by modeling the shape and the width of the dust features; (4) probe whether dust settling has occurred, via a self-consistent radiative transfer code incorporating dust settling, grain coagulation, and transfer processes. To reach these ambitious goals we have assembled a team with strong experience in all aspects of the topic. With team members participating in the FEPS and c2d Legacy programs we already have experience with IRS data reduction. Our proposed observations and the subsequent analysis will paint the first global picture of substellar disks and answer the questions whether BD disks are similar to those of low-mass stars, to what extent dust processing occurred and whether they are capable of forming planetary systems - or they already have.

Spitzer Space Telescope - General Observer Proposal #20544

Metallicity and Gravity Diagnostics in the Coldest Brown Dwarf Spectra

Principal Investigator: Adam Burgasser
Institution: Massachusetts Institute of Technology

Technical Contact: Adam Burgasser, Massachusetts Institute of Technology

Co-Investigators:
J. Davy Kirkpatrick, IPAC/Caltech
Chris Tinney, AAO
Adam Burrows, University of Arizona

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap IrsStare
Hours Approved: 20.7

Abstract:
Brown dwarf spectra are rich in diagnostics of temperature, gravity and metallicity. However, in the coldest sources, these parameters can be entangled with competing effects for a few major absorbers. We have identified three late-type T dwarfs that exhibit spectroscopic and kinematic indications of being either old, metal poor or both. We propose IRAC photometry and IRS spectroscopy of these sources to determine a means of breaking the so-called metallicity/gravity degeneracy, and to test the first generation of cold brown dwarf models exploring metallicity variations.

Spitzer Space Telescope - Directors Discretionary Time Proposal #251

Old and Cold: Identifying and Characterizing the Coldest Stellar and Substellar Halo Subdwarfs

Principal Investigator: Adam Burgasser
Institution: Massachusetts Institute of Technology

Technical Contact: Adam Burgasser, Massachusetts Institute of Technology

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap IrsStare
Hours Approved: 19.8

Abstract:
Wide-field near-infrared surveys such as 2MASS, DENIS, and SDSS have uncovered a vast population of ultracool stars and brown dwarfs in the Solar Neighborhood, the majority of which are Solar metallicity members of the disk population. In the past year, a number of ultracool dwarfs with spectral features indicating subsolar metallicity, as well as halo kinematics, have been identified. These ultracool subdwarfs extend into the late-type M and L spectral classes, a regime in which condensate dust plays an increasingly important role in the emergent spectral energy distributions of disk dwarfs. Because dust grains, and indeed many of the dominant absorption features in ultracool dwarfs, are comprised of metals, differences in overall atmospheric metallicity will have a substantial effect on the spectral morphology, cloud formation processes, and evolution of M, L, and T-type stars and brown dwarfs. As part of a comprehensive investigation of metal-poor ultracool dwarfs, I will undertake Spitzer IRAC and IRS observations of several of the coolest currently known subdwarfs and, through comparison to observations of disk dwarfs, search for diagnostics of metallicity. Further comparison to spectral models will enable the determination of the physical properties of these low-mass stars and brown dwarfs while also providing important feedback into our theoretical understanding of cool atmospheres. These observations are part of the PIs Spitzer Fellowship.

Spitzer Space Telescope - General Observer Proposal #3259

Mid-Infrared Spectroscopy of the Coldest Known Brown Dwarf 2MASS 0415-0935: Physical Diagnostics and Spectral Modeling

Principal Investigator: Adam Burgasser
Institution: Massachusetts Institute of Technology

Technical Contact: Adam Burgasser, Massachusetts Institute of Technology

Co-Investigators:
Derek Homeier, University of Georgia
J. Davy Kirkpatrick, IPAC/Caltech
Peter Hauschildt, Universitat Hamburg
France Allard, Ecole Normale Superieure
Ian McLean, UCLA

Science Category: brown dwarfs/very low mass stars
Observing Modes: IrsStare
Hours Approved: 1.2

Abstract:
We propose to obtain 5-22 micron low-resolution spectroscopy for the coldest known brown dwarf, 2MASS 0415-0935, using the IRS instrument on Spitzer. With an effective temperature of ~700-800 K, this source is a benchmark for the study of low temperature atmospheres and a key starting point for the search for even cooler brown dwarfs. The proposed observations will sample the brightest continuum emission region for this object and resolve many individual molecular features, including the important 10.5 micron band of NH3, the only detectable nitrogen-bearing molecule in a brown dwarf atmosphere and a tracer of atmospheric dynamics. By combining the Spitzer data with high signal-to-noise, moderate resolution optical (0.6-1.0 micron) and near-infrared (1.0-2.4 micron) ground-based data already obtained by our group, and matching to our state-of-the-art spectral models, we will be able to derive the physical properties of this source (temperature, surface gravity, and metallicity), as well as test current opacity models for H2O, CH4, and NH3, critical for modeling and interpreting brown dwarf and planetary atmospheres. The proposed program is a focused experiment for measuring the physical parameters of the coolest brown dwarfs now known and soon to be discovered, and provides a key empirical test of atmosphere models used for both substellar and planetary studies.

Spitzer Space Telescope - General Observer Proposal #50059

Direct Observations of Clouds on Brown Dwarfs: A Spitzer Study of Extreme Cases

Principal Investigator: Adam Burgasser
Institution: Massachusetts Institute of Technology

Technical Contact: Adam Burgasser, Massachusetts Institute of Technology

Co-Investigators:
Michael Cushing, U. Arizona
Kelle Cruz, American Museum of Natural History
Mark Marley, NASA AMES
Didier Saumon, Los Alamos National Laboratories
Dagny Looper, U. Hawaii
Patrick Lowrance, SSC
J. Davy Kirkpatrick, Caltech/IPAC

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap IrsStare
Hours Approved: 14.0

Abstract:
Clouds play a fundamental role in the emergent spectral energy distributions and observed variability of very low mass stars and brown dwarfs, yet hey have only been studied indirectly thus far. Recent indications of a broad silicate grain absorption feature in the 8-11 micron spectra of mid-type L dwarfs, and evidence that the strength of this absorption varies according to broad-band near-infrared color, may finally allow the first direct studies of clouds and condensate grain properties in brown dwarf atmospheres. We propose to observe a sample of 18 ‘‘extreme’’ L dwarfs - objects with unusually blue and red near-infrared colors - with IRAC and IRS to study the 8-11 micron feature in detail (including grain size distributions and bulk compositions), and to constrain advanced condensate cloud atmosphere models currently in development. Our program provides a unique examination of the general processes of cloud formation by focusing on the relatively warm photospheres of late-type brown dwarfs.

Spitzer Space Telescope - General Observer Proposal #40325

Time-resolved observations of a roasted brown dwarf

Principal Investigator: Matt Burleigh
Institution: University of Leicester

Technical Contact: Matt Burleigh, University of Leicester

Co-Investigators:
Pierre Maxted, University of Keele
Ralf Napiwotzki, University of Hertfordshire
Paul Dobbie, Anglo-Australian Observatory
Carolyn Brinkworth, Spitzer Science Center
Donald Hoard, Spitzer Science Center
Stefanie Wachter, Spitzer Science Center
Adam Burrows, University of Arizona
Emma Hogan, University of Leicester

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap
Hours Approved: 4.2

Abstract:
Irradiation of substellar brown dwarfs and hot Jupiters in close binaries can increase their surface temperatures by an order of magnitude, alter their radii and atmospheric structure, and lead to moderate mass loss. In these synchronously rotating systems, substantial temperature diffences between the "day" and "night" sides could lead to strong winds and jet streams transporting heat to the "night" side. Variations between the brightness of the "day" and "night " sides of the hot Jupiter upsilon And b have recently been detected by Spitzer, but the contrast between star and planet prevents a more detailed investigation. WD0137-349 is a unique close, detached binary containing a white dwarf and a substellar secondary. The brown dwarf is clearly detected at near-IR and mid-IR wavelengths. The hemisphere of the 0.053Msun brown dwarf facing the 16,500K white dwarf intercepts ~1% of its light and is being heated through irradiation. K-band photometry reveals +/- 15% variations between the "day" and "night" hemispheres. A short IRAC observation in Cycle 3 also reveals significant variability over a period of just ten minutes. These data strongly suggest that there are significant differences in luminosity and temperature between the "day" and "night" hemispheres. We will obtain time-resolved IRAC photometry of WD0137-349 in all four channels over the entire 116 minute orbital period to make a detailed investigation of the heating effects on the brown dwarf’s atmosphere, and to accurately measure the temperature across the entire surface. These observations will help us to understand how irradiation affects the atmospheric structure and evolution of very cool, low mass objects, and to develop and test new atmospheric models for irradiated brown dwarfs and hot Jupiters.

Spitzer Space Telescope - Directors Discretionary Time Proposal #527

The first T8+ benchmark

Principal Investigator: Ben Burningham
Institution: University of Hertfordshire

Technical Contact: Ben Burningham, University of Hertfordshire

Co-Investigators:
David Pinfield, University of Hertfordshire
Sandy Leggett, Gemini Observatory Northern Operations Centre
Derek Homeier, Georg-August Univsersitat
Phillip Lucas, University of Hertfordshire

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap IrsStare
Hours Approved: 7.7

Abstract:
We have discovered the first T8+ dwarf in a benchmark system. ULAS J2146-0010 has a spectral type of T8.5, and is a confirmed common proper motion binary companion with the M4 dwarf LHS3708. This object already has a well measured parallax and we have been able to place age and metallicity constraints on the pair. With an absolute J band magnitude of 17.68, this object is clearly extremely cool, and we have already estimated that Teff ~ 600K. We are requesting 7.7 hours of Spitzer Director's discretionary time to obtain IRAC imaging and IRS spectroscopy of this exciting object. These data will accurately constrain the mid-IR flux of the T8+, and combined with our NIR JHK spectroscopy and photometry, allow the bolometric flux of the object to be accurately determined. The parallax distance of the binary (12.5pc measured for the primary M4 star) will then directly give the luminosity of the T8+, and the age and metallicity constraints for the system (3.5-6 Gyr and -0.06 dex respectively, from measurements of the primary) will then combine to give the radius and mass of the T8+. A robust Teff will then come directly from the luminosity and radius constraints, providing a comprehensive set of physical properties for this benchmark object, and offering an unprecedented testbed for atmosphere models in the newly explored <700K temperature regime.

Spitzer Space Telescope - Directors Discretionary Time Proposal #238

Detecting Brown Dwarfs in Interacting Cataclysmic Binaries

Principal Investigator: Howard Chun
Institution: Cranston High School East

Technical Contact: Steve Howell, National Optical Astronomical Observatory

Co-Investigators:
Linda Stefaniak, Allentown High School
Beth Thomas, East Middle School
Doris Daou, Spitzer Science Center

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap
Hours Approved: 0.5

Abstract:
Recent observations and research indicate that interacting binaries may harbor brown dwarfs (BD) as the mass donor if their orbital periods are less than about 90 minutes. One such system, EF Eri, has been proven to contain a BD mass donor (Harrison, Howell, et al, 2004 ApJ, 614, 947). After a correlation of the 2MASS database with known ultra-short period binaries, three systems have been identified that have orbital periods less than about 90 minutes and contain highly magnetic white dwarfs (similar to EF Eri) which are likely to contain brown dwarfs. In the near-IR (JHK bands), interacting binaries with magnetic white dwarfs can create complex spectral energy distributions (SED). The accretion flux can often be observed in the near-IR. In addition, the high magnetic fields (30MG) typical of polars can also contribute heavily in the near-IR in the form of cyclotron humps. These humps are most prominent in the 6000 Angstrom to 2.5 micron range. To complete the SED or spectral picture of these interacting binaries, the longer wavelength IR needs to be added. The mass donor (whether an M star or brown dwarf) will radiate into the IR and should be clearly identifiable at wavelengths longer than those possibly contaminated. By using the Spitzer Infrared Array Camera (IRAC) the SED of the mass donor star can be isolated and the spectral type can be determined.

Spitzer Space Telescope - Directors Discretionary Time Proposal #267

Deciphering IR Excess Observed by the Spitzer Space Telescope in Short Period Interacting Cataclysmic Binaries

Principal Investigator: Howard Chun
Institution: Cranston High School

Technical Contact: Steve Howell, National Optical Astronomical Observatory

Co-Investigators:
Linda Stefaniak, Allentown High School
Beth Thomas, West Elementary School
Steve Howell, National Optical Astronomical Observatory
Don Hoard, Spitzer Science Center
David Ciardi, Michelson Science Center
Carolyn Brinkworth, Spitzer Science Center

Science Category: brown dwarfs/very low mass stars
Observing Modes: IrsStare
Hours Approved: 1.4

Abstract:
During the first year of the Spitzer Space Telescope Observing Program for Students and Teachers, our team observed a small sample of short orbital period interacting white dwarf binaries. Our scientific investigation was aimed at detection and characterization of the low mass, cool, brown dwarf-like mass donors in these systems. We used the Infrared Array Camera to obtain photometric observations of the polars EF Eri, GG Leo, V347 Pav, and RX J0154.0-5947 at 3.6, 4.5, 5.8, and 8.0 microns. In all our targets, we detected excess emission in the 3-8 micron region over that expected from a brown dwarf alone. One of the exciting discoveries we made with our IRAC observations is that the star EF Eri was found to be unexpectedly bright in the mid-IR (compared to its 2MASS magnitudes). This fact highlights an opportunity for us to observe EF Eri with the IRS as a follow-up proposal. EF Eri has a flux level of ~700 ?Jy at 8 microns. Thus, we are asking for time to obtain IRS data for only this star, our brightest source. We plan to obtain SL1 (7.4-14.5 microns) and SL2 (5.2-8.7 microns) spectroscopy only. We know the IRAC fluxes so our integration times are well constrained and the spectral region covered by SL1, SL2 will yield sufficient S/N to differentiate between cool dust (rising BB like spectrum with PAH and other molecular features allowing us to determine dust size, temperature, and disk extent) and a T type dwarf showing characteristic spectral signatures and a falling Rayleigh-Jeans tail.

Spitzer Space Telescope - Directors Discretionary Time Proposal #284

Nearby, Young Brown Dwarfs: A Comprehensive Study

Principal Investigator: Kelle Cruz
Institution: AMNH

Technical Contact: Kelle Cruz, American Museum of Natural History

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap MipsPhot
Hours Approved: 13.9

Abstract:
I have spectroscopically identified over 30 brown dwarfs with low-gravity spectral features indicating ages of 5-50 Myr. While over two-thirds of are likely members of the young (8-50Myr) loose associations in the southern hemisphere, the other objects are far removed from the young associations of the south and suggest one or more previously unrecognized groups in the northern hemisphere. I propose to lead a multi-faceted project aimed at understanding the nature and origin of a new population of juvenile brown dwarfs. This investigation will have ramifications for our understanding of the formation and evolution of disks, brown dwarfs, planets and, with the possible identification of new young stellar associations, star formation at all masses.

Spitzer Space Telescope - General Observer Proposal #3136

The Mid-Infrared Spectrophotometric Properties of a Complete Sample of the Nearest L Dwarfs

Principal Investigator: Kelle Cruz
Institution: American Museum of Natural History

Technical Contact: Kelle Cruz, American Museum of Natural History

Co-Investigators:
Neill Reid, Space Telescope Science Institute
Adam Burrows, University of Arizona

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap IrsMap IrsStare
Hours Approved: 20.2

Abstract:
We propose to obtain IRS short-low spectroscopy and IRAC photometry of a statistically complete, volume-limited (d<20pc) sample of 48 L dwarfs. These observations will provide the greatly needed data to constrain the properties of the dust clouds present in L dwarfs as well as the fundamental physical properties such as effective temperature, gravity, and metallicity. The mid-infrared observations will be combined with optical and near-infrared to compile a detailed spectral energy distribution for each object. With this extensive spectral coverage of the nearest and brightest objects, this dataset will prove to be the reference for L dwarf spectrophotometric standards.

Spitzer Space Telescope - General Observer Proposal #20409

Probing the Chromospheres of M dwarfs with the IRS

Principal Investigator: Michael Cushing
Institution: University of Arizona

Technical Contact: Michael Cushing, University of Arizona

Co-Investigators:
James Liebert, University of Arizona
Rainer Wehrse, University of Heidelberg
Peter Hauschildt, University of Hamburg
Gilles Chabrier, Ecole Normale Sup. de Lyons

Science Category: brown dwarfs/very low mass stars
Observing Modes: IrsStare
Hours Approved: 4.2

Abstract:
Arguable the most effective wavelength region to probe the coolest, outer layers of M dwarf atmospheres is to use mid-infrared spectrophotometry. Here the continuum opacity is very small, though if the atmosphere is not heated from below, the opacity due to water will be very strong. However, if there is any temperature increase above the minimum temperature layer due to a chromosphere or just weak acoustic heating, the water opacity weakens greatly, and a substantial increase in mid-infrared flux is predicted by models. This enhancement would be expected to increase sharply with increasing wavelength, reaching perhaps a 50% difference at 30 microns, and exceeding 60% at 36 microns. We thus propose to observe a set of eleven M1-M6 dwarfs, with and without quiescent H alpha emission. Most of the latter have old disk / halo space velocities. The observations should test the level of "basal" chromospheric-like activity for old stars that should have at most, weak, spun-down dynamos.

Spitzer Space Telescope - General Observer Proposal #50367

Precision Tests of Ultracool Dwarf Atmospheric Models

Principal Investigator: Michael Cushing
Institution: University of Arizona

Technical Contact: Michael Cushing, University of Arizona

Co-Investigators:
Michael Liu, IfA, University of Hawaii
Didier Saumon, Los Alamos National Laboratory
Mark Marley, NASA Ames
Trent Dupuy, IfA, University of Hawaii

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap IrsStare
Hours Approved: 20.7

Abstract:
Theoretical models of ultracool atmospheres are fundamental tools for understanding and characterizing brown dwarfs and extrasolar planets. However, current tests of these models are impeded by the heterogenous nature of field L and T dwarfs. We propose to circumvent this limitation by studying a careful chosen set of ultracool dwarfs with independently determined ages and/or masses. These "benchmark" objects can provide the most stringent tests currently possible for atmospheric models, a factor of ~5 more precise than typical field objects. With our proposed IRS Short-Low spectroscopy and IRAC photometry, in combination with existing optical/near-IR spectroscopy, we will construct high S/N 0.9-14.5 SEDs and compare to state-of-the-art theoretical atmospheric models. The mid-IR provides essential information about several fundamental spectral diagnostics (CO, H2O, CH4, and NH3) and the overall emergent flux. Thus, our proposed Spitzer observations are critical to testing and thereby improving the models. Without these data, such precise tests of ultracool atmospheres will not be possible until the availability of JWST.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30179

T Dwarf Variability

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Brian Patten, Harvard-Smithsonian

Co-Investigators:
Brian Patten, Smithsonian Astrophysical Observatory
Joseph Hora, Smithsonian Astrophysical Observatory
Massimo Marengo, Smithsonian Astrophysical Observatory
John Stauffer, Spitzer Science Center
Kevin Luhman, Penn State University

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap
Hours Approved: 7.0

Abstract:
We are proposing to use IRAC to conduct a variability study of seven T dwarfs covering a variety of mid- to late-T dwarf spectral sub-types to assess the amplitude of variability over time scales of days, weeks, months, and years. This study of T dwarf variability in the mid-IR will address three questions: (1) what is the amplitude of variability seen for T dwarfs across a wide variety of temperatures?, (2) what is the time scale of the variability (i.e. is it primarily rotationally modulated (hours)) or do longer time scales (weeks, months, years) related to slower atmospheric changes dominate?, and (3) how much of the observed scatter in T dwarf colors, as observed by IRAC, could be due to variability? Ultimately we hope to determine whether T dwarfs have relatively featureless atmospheres or have more in common with giant planet atmospheres. The monitoring campaign being proposed here is the first step in determining level of variability that can be seen in the T dwarfs in the mid-IR as a part of evaluating the feasibility of future long-term monitoring of these objects with IRAC.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #33

A Search for Companions Around Stars Within Five Parsecs

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Tom Megeath, Harvard, CfA

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap
Hours Approved: 8.2

Abstract:
Each star known within 5 parsecs of the Sun will be observed with IRAC to discover very low mass companions. Simply because of their proximity, these targets promise to provide one of the most sensitive experiments possible with IRAC --- the detection of super-Jupiters around the nearest stars. Depending on distance and separation from the stars, companions with masses as low as 5-20 Mjup can be detected. The sample of 60 stars in 44 systems within 5 parsecs requires 45 IRAC pointings (Proxima Cen requires its own pointing because it is two degrees from alpha Cen). The sample includes 4 white dwarfs, 1 A star (Sirius), 1 F star (Procyon), 2 G stars (alpha Cen A and tau Ceti), 6 K stars, and 46 M stars. These stars comprise 30 single systems, 10 doubles, and 3 triples, as well as the nearest star with a probable extrasolar planet, Gl 876.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #34

Substellar Mass Companions to Nearby Young Stars

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Tom Megeath, Harvard, CfA

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap
Hours Approved: 13.0

Abstract:
Seventy-three nearby (d < ~30 pc), young dwarfs with types ranging from A0V to M4.5V will be observed with IRAC to detect companions with masses as low as 5 - 20 M_Jup. The advantage of observing targets which are young is that substellar mass companions will also be young and therefore much more luminous than their cooler counterparts found around older stars in the field. The targets in this program have been selected from the literature using multiple indicators of youth (age < 120 Myr) including high X-ray luminosity, high chromospheric activity levels, high Li abundance, rapid rotation, photometric colors consistent with youth (when combined with theoretical isochrones), and young disk kinematics. This volume-limited sample will allow us to search for companions on distance scales of 50 AU to 4000 AU from the primary.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #35

Multiplicty and Infrared Colors of Nearby MLT Dwarfs

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Tom Megeath, Harvard, CfA

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap
Hours Approved: 16.1

Abstract:
Eighty nearby, low mass dwarfs of type M5.0V and later will be observed with IRAC to discover companions with masses as low as 10-20 Mjup. These targets are ideal for a companion search because they are nearby, yet relatively faint. This allows low mass companions to be revealed close to the target object because the psf of the primary isn't overwhelming. The mass limit of 10-20 Mjup (depending on target distance) for this survey is for 30 sec integrations in the 4.5 micron band. In addition to the companion search, this study will provide double duty because the targets themselves are the ideal calibrators for other IRAC brown dwarf search programs.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #36

Deep IRAC Imaging of Brown Dwarfs in Star Forming Clusters

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Tom Megeath, Harvard, CfA

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap IrsStare
Hours Approved: 21.9

Abstract:
Deep IRAC imaging will be used to measure 1) the substellar IMF (>0.5-1 M_jup) and 2) the 1-8um SEDs of young brown dwarf/disk systems (>1-2 M_jup) within the three nearby star forming clusters (0.5-2 Myr) of IC 348 (300 pc), Rho Oph (150 pc), and Cha I (150 pc). The maps of these clusters will have dimensions of 15'x15', 10'x10', and 15'x15' and total exposure times per pointing of 3000, 3000, and 2000 s.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #38

IRAC Imaging of the Pleiades

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Tom Megeath, Harvard, CfA

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap
Hours Approved: 19.1

Abstract:
Imaging in all four IRAC bands will be obtained for members of both clusters ranging in mass from the top of the main sequence to the faintest known cluster members, using the "cluster" mode. One goal of the observations will be to define the single-star main sequencen the four IRAC bands at (a) solar metallicity and age ~ 100 Myr (i.e. members of the Pleiades) and (b) at [Fe/H] ~ +0.14 and age ~ 600 Myr (i.e. members of the Hyades). In the Pleiades, this will include obtaining IRAC photometry for most of the known or proposed sub-stellar members of the cluster. Comparison of the IRAC colors for the sub-stellar Pleiades members to older VLM stars (and to very young, sub-stellar objects identified in star-forming regions) will help to empirically establish the gravity sensitivity of the IRAC colors at very low masses. A second goal of the observations will be to search for previously unknown, very low mass members of the cluster, either as companions to the targeted members or as "free-floating" cluster members that happen to be located near the targeted members. The goal of the observations of the target objects is to obtain photometry with intrinsic S/N ~ 1% in all four IRAC bands (or 2% in the SiAs bands for the faintest targets) in order to define the IRAC CM and CC diagrams as precisely as possible. The goal for the search for new, even lower mass Pleiades members is to be able to detect substellar mass members of the Pleiades down to 10 M(Jup) at 4.5 microns.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40198

T Dwarf Explorer

Principal Investigator: Giovanni Fazio
Institution: Smithsonian Astrophysical Observatory

Technical Contact: Brian Patten, Smithsonian Astrophysical Observatory

Co-Investigators:
Brian Patten, Smithsonian Astrophysical Observatory
Massimo Marengo, Smithsonian Astrophysical Observatory
Joseph Hora, Smithsonian Astrophysical Observatory
John Stauffer, Spitzer Science Center
Kevin Luhman, Pennsylvania State University
Sarah Sonnett, University of Hawaii

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap
Hours Approved: 6.5

Abstract:
With the basic colors and photometry for M, L, and T dwarfs in the IRAC bandpasses established (Patten et al. 2006), we wish to shift our focus to the differences seen among objects with similar T_eff and, in particular, to expand on the exploration of the T dwarfs. While some of the observed dispersion of T dwarf colors and magnitudes in the near- and mid-IR for objects of the same sub-type can be explained by differences in metallicity and gravity, some of this scatter may also be due to binarity and intrinsic variability (i.e., "brown dwarf weather"). We are curious as to whether or not the observed scatter with color in the infrared, which appears to be largest in the mid-T dwarfs, really tapers off and grows smaller in the late-T dwarfs, or if we are simply not seeing the whole picture due to small number statistics. On the warmer end of the T sequence, recent results suggest that the transition from the late-L to early-T types in brown dwarf temperature progresses very quickly in an evolutionary sense. Therefore, objects with early T types should be relatively rare. Many of the early-T brown dwarfs used in the in the Patten et al. 2006 study (and others) have turned out to be very close binaries (e.g. Burgasser et al. 2006), which has resulted in a deficit of true, single early-T brown dwarfs with well-determined mid-infrared colors and photometry. We are proposing to acquire IRAC photometry for an additional ~23 T-type dwarfs in order to allow us to better characterize trending with color and spectral type for the T dwarfs. These new T dwarf data will be combined with the existing T dwarf data previously acquired by IRAC to produce the color-color and color-magnitude diagrams necessary to compare observation to theory for the coolest sub-stellar mass objects known. These data will prove invaluable in constraining searches in color and magnitude space for brown dwarf companions to nearby stars as well as for free-floating brown dwarfs in the field.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40228

Searching for Companions to a New Member of the 5 pc Sample

Principal Investigator: Giovanni Fazio
Institution: Smithsonian Astrophysical Observatory

Technical Contact: Massimo Marengo, Smithsonian Astrophysical Observatory

Co-Investigators:
Massimo Marengo, Smithsonian Astrophysical Observatory
Kevin Luhman, Pennsylvania State University
Brian Patten, Smithsonian Astrophysical Observatory/NSF
Joseph Hora, Smithsonian Astrophysical Observatory
John Stauffer, Spitzer Sciance Center
Michael Schuster, University of Minnesota/SAO
Peter Allen, Pennsylvania State University
Joseph Carson, Jet Propulsion Laboratory
Richard Ellis, Brown University

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap
Hours Approved: 0.2

Abstract:
The IRAC GTO team has used IRAC to search for brown dwarf companions to all known stars and brown dwarfs within 5 pc from the Sun. A new member of the solar neighborhood, SCR 1845-6357 (M8.5V), has been recently discovered at a distance of 3.85 pc, making it the 24th closest object to the Sun (Hambly et al. 2004; Henry et al. 2006). High-resolution imaging has revealed a T dwarf companion at a separation of 1" from this star (Biller et al. 2006). We propose to obtain IRAC images of SCR 1845-6357 to search for additional brown dwarf companions at wider separations.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #42

IRAC Imaging of the Hyades

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Tom Megeath, Harvard, CfA

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap
Hours Approved: 18.0

Abstract:
Imaging in all four IRAC bands will be obtained for members of the Hyades and Pleiades clusters ranging in mass from the top of the main sequence to the faintest known cluster members, using the "cluster" mode. One goal of the observations will be to define the single-star main sequence in the four IRAC bands at (a) solar metallicity and age ~ 100 Myr (i.e. members of the Pleiades) and (b) at [Fe/H] ~ +0.14 and age ~ 600 Myr (i.e. members of the Hyades). In the Pleiades,this will include obtaining IRAC photometry for most of the known or proposed sub-stellar members of the cluster. Comparison of the IRAC colors for the sub-stellar Pleiades members to older VLM stars (and to very young, sub-stellar objects identified in star-forming regions) will help to empirically establish the gravity sensitivity of the IRAC colors at very low masses. A second goal will be to search for previously unknown, very low mass members of the cluster, either as companions to the targeted members or as "free-floating" cluster members that happen to be located near the targeted members.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #48

Brown Dwarfs Around Extrasolar Planetary Candidates

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Tom Megeath, Harvard, CfA

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap
Hours Approved: 8.5

Abstract:
Forty-eight stars with extrasolar planet candidates will be observed to detect additional, wider companions with masses as low as 20 Mjup. The most important question that might be answered by observing these stars with IRAC is: "Are there brown dwarf companions in the systems at larger radii?" There are currently only two main sequence stars --- the Sun and upsilon Andromedae --- known to have more than one companion of planetary mass. If a brown dwarf were discovered in addition to a planetary companion around one of these stars, it would have serious implications for the formation of solar systems. In fact, the nature of brown dwarfs themselves might come into play, e.g. might brown dwarfs sometimes be considered planetary bodies?

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50604

Proper Motion Search for T-Dwarfs

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Massimo Marengo, Harvard-SAO

Co-Investigators:
Massimo Marengo, Smithsonian Astrophysical Obs
Joseph Hora, Smithsonian Astrophysical Obs.
Kevin Luhman, Pennsilvania State University
Brian Patten, NSF/ Smithsonian Astrophysical Obs.
Michael Schuster, Smithsonian Astrophysical Obs.

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap
Hours Approved: 5.0

Abstract:
We propose to perform a search for foreground T-dwarf candidates in the SAGE survey field. Candidate objects will be identified by using the k-NN method applied to the mosaic photometry version of the SAGE database. We will image the fields again with the IRAC 4.5/8.0 micron bands to obtain a 'second epoch' to determine if the candidate objects have sufficient proper motion for them to be true T-dwarfs, and to search the fields for additional companion objects with common proper motions. The newly identified objects will expand the sample of known T-dwarfs and explore the full range of characteristics of this brown dwarf class.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50

IRAC Imaging of the Trapezium and NGC 2024 Clusters

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Tom Megeath, Harvard, CfA

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap
Hours Approved: 2.1

Abstract:
We will obtain IRAC images of 15'x15' fields in the Trapezium and NGC 2024 to complement the IRAC Orion survey. This data will provide: 1.) deep imaging of the Trapezium cluster from which we will obtain IRAC photometry of brown dwarf candidates, 2.) accurate photometry in regions of high surface brightness.

Spitzer Space Telescope - General Observer Proposal #20716

Spitzer Observations of the Most Active L Dwarf

Principal Investigator: John Gizis
Institution: University of Delaware

Technical Contact: John Gizis, University of Delaware

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap IrsStare
Hours Approved: 0.9

Abstract:
We propose IRAC photometry and IRS spectroscopy of the L5 dwarf 2MASSI 1315309-364951. This L5 dwarf has strong, persistent H alpha emission that is more than 100 times greater than the type late-L dwarf. Our proposed Spitzer observations will rule in or our a number of scenarios that might lead to the unique activity seen in this object. We will determine the photospheric temperature of this object, and by comparing to other Spitzer L dwarfs, determine if it has an unusual mass or composition.

Spitzer Space Telescope - General Observer Proposal #3562

Coronal and Chromospheric Heating in Active Dwarf Stars

Principal Investigator: John Gizis
Institution: University of Delaware

Technical Contact: John Gizis, University of Delaware

Co-Investigators:
Dermott Mullan, University of Delaware

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap MipsPhot
Hours Approved: 3.9

Abstract:
We propose to observe a sample of highly active M dwarfs with IRAC and MIPS. Such active dwarfs are known to have large infrared excesses. We argue that the excesses are likely to result from the hot chromospheres and coronae above the photosphere. In this context, our proposed measurements of the (excess) infrared spectral energy distribution will allow us to reliably map the temperature rise in the chromosphere.

Spitzer Space Telescope - General Observer Proposal #3626

Searching for Disks in TW Hya Association Brown Dwarfs

Principal Investigator: John Gizis
Institution: University of Delaware

Technical Contact: John Gizis, University of Delaware

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap MipsPhot
Hours Approved: 1.0

Abstract:
We propose to obtain IRAC and MIPS (24 micron) imaging of two 2MASS-discovered brown dwarfs in the TW Hya Assocation. These substellar objects are about 25 times the mass of jupiter, 11 million years old, and 50 parsecs away. They thus offer the opportunity to search for IR excesses due to a disk in a closer, less confused region than Orion or other star forming regions. Substantial evidence already exists that one of our targets is currently accreting from a disk. The IRAC data will complement our X-Ray, UV, and optical observations aleady obtained or scheduled. As a side benefit, our observations are also sensitive to planetary companions, if any exist at extreme (1000+ AU) separation, and will test model atmospheres of young brown dwarfs.

Spitzer Space Telescope - General Observer Proposal #3736

Atmospheric variability in brown dwarfs with IRAC

Principal Investigator: Bertrand Goldman
Institution: NMSU, NASA/Ames

Technical Contact: Bertrand Goldman, NMSU, NASA/Ames

Co-Investigators:
Michael Cushing, NASA
Mark Marley, NASA
Eduardo Martin, IAC
Keith Noll, STScI
Denise Stephens, STScI

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap
Hours Approved: 16.0

Abstract:
We propose to use IRAC to study brown dwarfs for atmospheric variability. We will observe a sample of brown dwarfs from L2 to T2 to test atmospheric models of the L/T transition. Atmospheric variability, that is expected by some models for these objects, would constrain the physical parameters of cloud vertical distribution, horizontal homogeneity and the dynamics of the very cool atmospheres. The existence and amplitude of the variations would reveal the size and distribution of the cloud cover over the surface of the brown dwarf and test a model explaining the rapidity of the L to T type transition. The relative color changes would constrain the vertical extent of dynamical process and the depth in the atmosphere at which they take place. If a periodicity is measured, the rotational period of the dwarf could be estimated. SST provides the unique and crucial opportunity in a new wavelength range, to observe beyond Earth atmospheric variable absorption, with adequate time resolution, particularly in the important water bands.

Spitzer Space Telescope - General Observer Proposal #20514

A Spectrophotometric Study of the L-T Dwarf Transition

Principal Investigator: David Golimowski
Institution: Johns Hopkins University

Technical Contact: David Golimowski, Johns Hopkins University

Co-Investigators:
Xiaohui Fan, University of Arizona
Thomas Geballe, Gemini Observatory
Sandy Leggett, Joint Astronomy Centre
Mark Marley, NASA/Ames Research Center
Didier Saumon, Los Alamos National Laboratory
Denise Stephens, Johns Hopkins University

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap IrsStare
Hours Approved: 42.3

Abstract:
Recent 1-5 micron studies of L and T dwarfs indicate that changes in the near-infrared spectra across the L-T transition are governed by complex cloud dynamics rather than by large changes in effective temperature. These studies also suggest that nonequilibrium chemistry significantly affects the photospheric abundances of CO, CH4, and NH3, all of which influence the spectral energy distributions from 1 to 15 micron. A focused study of L-T transition dwarfs longward of 5 micron is crucial to understanding the agents that govern the dynamic and chemical processes in the atmospheres of these brown dwarfs. We request 39.7 hours of IRS time in Cycle 2 to study 7 late-L and early-T dwarfs. This proposal is an extension of our similarly aimed Cycle 1 proposal. Our combined Cycle 1 and Cycle 2 samples will be 40% larger than the number of L-T transition dwarfs observed with IRS by the GTO team, and will include dwarfs with extremely blue and extremely red near-infrared colors. We also request 2.6 hours of IRAC time in Cycle 2 to obtain four-band photometry of 9 L-T transition dwarfs from our Cycle 1 and 2 programs. By combining the IRS and IRAC data with our existing 0.8-2.5 micron spectra and 0.9-2.2 micron photometry, we will (1) investigate the effects of grain condensation, metallicity, and nonequilibrium chemistry on the atmospheres of these brown dwarfs and (2) accurately determine the bolometric fluxes of the dwarfs in our Cycle 1 and 2 programs. Our comprehensive data set will allow us to constrain models of the transition from dusty red L dwarfs to clear blue T dwarfs and to determine the importance of nonequilibrium chemistry in defining the L-T transition.

Spitzer Space Telescope - General Observer Proposal #20101

Day and Night on Hot Jupiters

Principal Investigator: Bradley Hansen
Institution: UCLA

Technical Contact: Bradley Hansen, UCLA

Co-Investigators:
Sara Seager, Carnegie Institute of Washington
Drake Deming, Goddard Space Flight Center
Jeremy Richardson, Goddard Space Flight Center
Joe Harrington, Cornell
Kristen Menou, Columbia University
James Cho, Carnegie Institute of Washington

Science Category: brown dwarfs/very low mass stars
Observing Modes: MipsPhot
Hours Approved: 7.6

Abstract:
Recent observations of the secondary eclipse of the 'Hot Jupiter' planet HD209458b suggest that the planet may reradiate most and perhaps all of the irradiation it receives from its host star on the side facing the star i.e. that there is little redistribution of energy around the surface of the planet. An immediate implication of this day/night temperature difference is that even non-transitting 'Hot Jupiter' planetary systems should show a small flux variation as the planet orbits the star, showing first its hot day side and then its cold night side. We propose to monitor the 24 micron flux variation of the five brightest stars that host Hot Jupiter planets, in order to detect the orbital modulation of the total star+planet flux. The detection of such variations will provide information on the nature and atmospheric dynamics of these planets and may even constrain the inclination of the orbital plane.

Spitzer Space Telescope - General Observer Proposal #50025

Deep IRAC/MIPS Photometry of Candidate Young Planetary Mass Objects

Principal Investigator: Paul Harvey
Institution: University of Texas

Technical Contact: Paul Harvey, University of Texas

Co-Investigators:
Katelyn Allers, University of Hawaii
Daniel Jaffe, University of Texas
Michael Liu, University of Hawaii

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap MipsPhot
Hours Approved: 49.9

Abstract:
We propose to map a 0.7 sq deg area of the Ophiuchus Cloud to very deep levels with IRAC and MIPS to identify a robust sample of young, planetary mass objects from a set of 39 candidates. We identified the candidates through previous deep near-IR imaging, c2d 3.6/4.5 micron detections, and have extracted low S/N 5.8/8 micron fluxes from existing c2d Legacy data. The 39 Ophiuchus candidates were then selected using color-magnitude criteria from our previous very successful search for higher luminosity brown dwarfs with disks. In order to determine which of these candidates is truly a young planetary mass object with a disk, we now require much deeper Spitzer observations at 5.8, 8, and 24 micron to obtain good S/N and to characterize the disks. We are also in the process of obtaining complementary near-IR narrowband photometry that will allow us to eliminate extra-galactic contaminants in our sample and to obtain spectral types for the cool sub-stellar objects. As a result, we will end up with a sample of well characterized young planetary-mass objects with and without disks and a similar number of field dwarfs. The wide field and very high sensitivity of Spitzer are essential to the success of this project. This combination of capabilities is unlikely to exist for a long time after the end of Spitzer's cryogenic mission.

Spitzer Space Telescope - General Observer Proposal #30536

Protoplanetary Disks Around Very Low-Mass Stars in the Coronet Cluster

Principal Investigator: Thomas Henning
Institution: Max-Planck-Institute for Astronomy

Technical Contact: Aurora Sicilia-Aguilar, MPIA

Co-Investigators:
Aurora Sicilia-Aguilar, Max-Planck-Institut fuer Astronomie, Heidelberg
Jeroen Bouwman, Max-Planck-Institut fuer Astronomie, Heidelberg
Bertrand Goldman, Max-Planck-Institut fuer Astronomie, Heidelberg
Gordon Garmire, Penn State University

Science Category: brown dwarfs/very low mass stars
Observing Modes: IrsStare
Hours Approved: 22.6

Abstract:
We propose to take IRS low-resolution spectra of a set of 16 very low-mass stars and brown dwarfs in the Coronet cluster. These objects, whose membership has been confirmed via X-ray and/or optical surveys, have been observed with IRAC and MIPS, revealing the presence of disks at different evolutionary stages, from optically thick accretion disks, to potential disks with inner gaps and maybe remnant ‘‘debris’’-like disks. With a relatively short program, these IRS observations will allow us to study one of the largest samples of very-low mass stars with disks at a very young age (~ 1 Myr) in one of the most interesting and nearby regions of recent and ongoing star formation, the Coronet cluster, located at 130 pc. We will examine the disk structure, the presence of inner gaps and walls (maybe related to planet formation), and the grain size and mineralogy, comparing them to the observations of higher-mass stars and to older populations of very low-mass stars and brown dwarfs (i.e., Chameleon, ~9 Myr), in order to determine whether the properties of their disks are similar, and whether the observable differences in disk structure and composition are a pure effect of time evolution, or may be related to the initial conditions of the stars and their formation and/or to the effects of environment.

Spitzer Space Telescope - General Observer Proposal #20103

A Survey of 5 Myr Disks around Brown Dwarfs in the Upper Scorpius OB Association

Principal Investigator: Lynne Hillenbrand
Institution: Caltech

Technical Contact: Catherine Slesnick, Caltech

Co-Investigators:
Catherine Slesnick, Caltech
Russel White, Caltech

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap MipsPhot
Hours Approved: 17.3

Abstract:
We propose to use the Spitzer Space Telescope to study the disks around 35 spectroscopically confirmed brown dwarfs in the Upper Scorpius OB association. The Spitzer data combined with our previous work on young brown dwarf stellar parameters, accretion rates, and binarity will allow us to address with the Upper Sco sample several fundamental questions regarding brown dwarf disk properties and evolution. IRAC and MIPS observations will allow us to determine very precise energy distributions from 3.6 to 24 microns, which is important for determining the circumstellar disk structure; photometrically calibrated 5 to 40 micron IRS spectra will allow us to determine disk composition. Most importantly, our proposed Spitzer program will probe sources in the as-yet unexplored ~5 Myr age-range when brown dwarfs are in the process of dissipating gas and dust in their disks and possibly assembling planets. Obtaining spectral energy distributions for brown dwarfs at this age combined with approved Spitzer GTO and GO programs of younger (<1-2 Myr) sources will determine an evolutionary sequence for the circumstellar material surrounding young substellar objects. Thus, we will be able to assess for the first time if brown dwarf disk chemistry and structure evolve in the same manner and on similar time scales as for disks around higher mass stellar objects.

Spitzer Space Telescope - General Observer Proposal #30237

The Scorched Atmosphere of a Low Mass Star

Principal Investigator: Dean Hines
Institution: Space Science Institute

Technical Contact: Dean Hines, Space Science Institute

Co-Investigators:
Gary Schmidt, The University of Arizona

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap
Hours Approved: 11.3

Abstract:
The recent detection of mid-IR emission from the brown dwarf companion to the white dwarf GD1400 (Farihi & Christopher 2005) demonstrates the power of IRAC for characterizing low-mass companions to white dwarf (WD) stars. Compared with GD1400, the close binary system SDSS121209.31+013627.7 (hereafter SDSS1212) is potentially a far more significant target in this effort. SDSS1212 consists of a magnetic WD plus a low-mass companion in a very close (tidally-locked) orbit (a ~ 0.6 Rsun, P ~ 90 mins). The companion shows the effects of irradiation of its atmosphere by the WD, and the tidal lock (and inclination) ensures that we view the illuminated and far-side hemispheres during each orbit. Ground-based, J-band upper limits constrain the companion to be a late-type brown dwarf (L5 or later). Thus, SDSS1212 is an ideal system for studying the atmosphere of a sub-stellar object heated by a strong continuum. Indeed, the total irradiating flux at ~1 Rsun from a T ~ 10,000K WD is comparable to that at r ~ 0.1 AU from a sun-like main sequence star, and SDSS1212 is the only WD + brown dwarf binary whose orbital period is known. Given its importance for the characterization of planetary atmosphere and binary star evolution, we propose to carry out phase-resolved 3.6?8 micron imaging of the SDSS1212 system with the dual goals of: 1) characterizing the orbit-averaged photometric properties of the low-mass companion, and thus discerning its placement within the ever-expanding zoo of substellar objects; and 2) measuring what is expected to be a modulation of up to 0.4 mag in the net mid-IR brightness of the binary, thereby providing an empirical point of comparison for current theoretical efforts to predict the response of "hot Jupiters" to irradiation by their parent stars. Coupled with the exquisite photometric stability of IRAC and the benign environment of Spitzer, this unique target offers an exceptional opportunity to study the effects of irradiation from host stars on their substellar companions.

Spitzer Space Telescope - General Observer Proposal #2314

Detecting the Brown Dwarf Secondary Stars in Cataclysmic Variables

Principal Investigator: Donald Hoard
Institution: IPAC, California Institute of Technology

Technical Contact: David Ciardi, Michelson Science Center

Co-Investigators:
Steve Howell, NOAO
Paula Szkody, U. of Washington
Tom Harrison, New Mexico State U.
Stefanie Wachter, SSC/IPAC/Caltech
Derek Homeier, University of Georgia
Gerard van Belle, MSC/IPAC/Caltech
David Ciardi, MSC/JPL
Carolyn Brinkworth, U. of Southampton/SSC/IPAC/Caltech

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap IrsStare
Hours Approved: 13.4

Abstract:
Cataclysmic variables (CVs) are semi-detached binary stars consisting of a white dwarf (WD) primary star that accretes material from a low mass secondary star, with typical orbital periods of less than 1 day. Eventually, the ongoing mass loss from the secondary star causes it to drop below the mass limit for hydrogen burning, and the secondary star becomes a degenerate brown dwarf (BD). Population synthesis studies predict that approximately 70% of all CVs should contain BD secondary stars. There is plausible indirect evidence for the existence of BDs in 39 CVs; however, there is currently no conclusive direct evidence for any CV containing a BD. Even if all of the potential candidates do indeed contain BD secondary stars, this is only a few percent of all CVs - a huge deficit compared to 70% of CVs predicted by population synthesis studies. We propose to observe 23 candidate CVs with BD secondary stars using the Infrared Array Camera and Infrared Spectrograph on the Spitzer Space Telescope to directly determine the spectral type of the secondary star. These 23 CVs represent the best candidates for detecting BD secondary stars with Spitzer. The proposed Spitzer study will allow us to ascertain the fraction of CVs containing BD secondary stars and allow us to constrain the explanation for the characteristics of the observed population of CVs.

Spitzer Space Telescope - Archive Research Proposal #30689

A White Dwarf-Based Investigation of the IRAC Photometric Absolute Calibration

Principal Investigator: Jay Holberg
Institution: University of Ariziona

Technical Contact: Jay Holberg, University of Ariziona

Co-Investigators:
Pierre Bergeron, University of Montreal

Science Category: brown dwarfs/very low mass stars
Dollars Approved: 55256.0

Abstract:
We propose a SPITZER Archive Program to use the extensive set of DA (pure hydrogen) white dwarfs in the SPITZER Science Archive to: 1) perform an independent investigation of the absolute calibration of the IRAC bands, 2) to evaluated the claim (Kilic et al. 2005) that cool white dwarfs possess unexplained flux deficits in the IRAC 4.5 micron and 8 micron channels, and 3) to systematically investigate the effects of Collisionally Induced Opacities and other opacity sources in cool white dwarfs. Our proposed data set consists primarily of the large set of those DA white dwarfs which have been observed with IRAC, AND which possess spectroscopically determined temperatures and gravities. These stars are placed on the HST photometric scale, with its well defined links to Vega, to optical fluxes, and to the 2MASS Near-IR bands. Model atmosphere fluxes, precisely matching the optical and 2MASS photometry and optical spectroscopy, are used to predict the corresponding IRAC fluxes. This procedure is demonstrated for a set of published IRAC observations.

Spitzer Space Telescope - General Observer Proposal #30856

Looking For Low Mass Companions To White Dwarfs In All The Right Places

Principal Investigator: Jay Holberg
Institution: University of Ariziona

Technical Contact: Jay Holberg, University of Ariziona

Co-Investigators:
Pierre Bergeron, University of Montreal
Martin Barstow, University of Leicester
Matthew Burleigh, University of Leicester
Paul Dobbie, University of Leicester
George Rieke, University of Arizona

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap
Hours Approved: 7.9

Abstract:
We propose a SPITZER GO program which seeks IRAC band excesses, due to the cool low mass companions to DA (pure hydrogen) white dwarfs. These data would: 1) confirm the existence of the companions, 2) better identify the spectral type of the companions, and 3) increase the number of known systems which contain very late M to early L companions. Our technique is unique in that it relies on DA white dwarfs with known spectroscopic temperatures and gravities, to predict the 2MASS JHKs magnitudes of the degenerate stars together with the observed 2MASS JHKs magnitudes, to determine net Near-IR excesses in each target. Since these excesses are well calibrated, it is possible to make first order estimates of the absolute magnitudes of the single late M and early L dwarf companions responsible for the excesses. In this way we can also focus on systems which contain relatively young white dwarfs, which maximize the thermal luminosity of any L dwarf companions, of which few examples are presently known.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #29

IRS observations of the dwarf M-star sequence

Principal Investigator: James R. Houck
Institution: Cornell University

Technical Contact: Thomas Roellig, NASA Ames Research Center

Science Category: brown dwarfs/very low mass stars
Observing Modes: IrsStare
Hours Approved: 9.3

Abstract:
M-dwarfs are the lowest-mass stars that still undergo a normal main-sequence phase. Studies of these objects are important for two reasons: (1) they are the stellar transition into the brown dwarf classes of objects, and (2) their low photospheric temperatures mean that the chemistry of their atmospheres changes radically as the M-star sequence is traversed. These observations use the IRS to observe a sample of M-dwarfs ranging from M0 to M9.5. The observations generally use the short-low and both high resolution modules.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30092

Temporal Spectral Variations in Brown Dwarf Atmospheric Fluxes

Principal Investigator: James R. Houck
Institution: Cornell University

Technical Contact: Thomas Roellig, NASA Ames Research Center

Co-Investigators:
Thomas Roellig, NASA Ames Research Center
Greg Sloan, Cornell University
Jeff Van Cleve, Ball Aerospace Corp.
John Wilson, University of Virginia
Amanda Mainzer, JPL
Michael Cushing, University of Arizona
Mark Marley, NASA Ames Research Center
Didier Saumon, Los Alamos National Laboratory
Davy Kirkpatrick, IPAC
Sandy Leggett, Joint Astronomy Centre, Hilo

Science Category: brown dwarfs/very low mass stars
Observing Modes: IrsMap
Hours Approved: 48.0

Abstract:
In general, low-mass Main Sequence and Brown Dwarf (BD) objects are rapid rotators, with rotational periods averaging approximately 4 hours. If there are any longitudinal spatial variations in the flux emitted from their atmospheres, either due to star spot-like patches or cloud features, the total flux should show some periodic variability on these time scales, assuming that the view angle is not pole-on. There may also be longer time- scale non-periodic variability if the star-spots or clouds change in size over time. We are proposing here to use the IRS instrument on Spitzer to further investigate the question of temporal variability in the mid-infrared flux from Brown Dwarfs. Although there have been earlier attempts with mixed success to see temporal variations in BD photometric fluxes, there are certain advantages to looking for temporal variations in the spectrum of an object rather than photometrically. We are proposing to re-observe four L or T-type Brown Dwarfs that have been previously observed with the IRS instrument and whose mid-infrared spectra are well-characterized, but with greatly increased observing time and at multiple epochs. Each target will be observed for almost 4 hours at a time over three different epochs spaced a few days apart within one IRS campaign. Observations over these time bases will allow studies both at typical BD rotation periods of hours, as well as checking for longer-period changes over periods of days. Finally, by comparing our results with our previous observation data we can check for variability on time scales of years.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #44

IRS observations of nearby stars

Principal Investigator: James R. Houck
Institution: Cornell University

Technical Contact: Thomas Roellig, NASA Ames Research Center

Science Category: brown dwarfs/very low mass stars
Observing Modes: IrsStare
Hours Approved: 1.0

Abstract:
SIRTF will conduct a survey of the nearest stars. Most of these objects are observed by the IRS in others programs devoted to M-star observations and nearby stars with known disk emission. The objects to be observed here are those that are not in this program nor are so bright that they would saturate the IRS instrument.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #51

IRS Observations of the Brown Dwarf L and T Sequence

Principal Investigator: James R. Houck
Institution: Cornell University

Technical Contact: Thomas Roellig, NASA Ames Research Center

Science Category: brown dwarfs/very low mass stars
Observing Modes: IrsStare
Hours Approved: 76.3

Abstract:
We examine the spectra of brown dwarfs in a study complementary to the IRS GTO proposal "IRS observations of the dwarf M-star sequence." These objects do not have sustained fusion, only temporary deuterium burning early in their evolution. L and T dwarfs are distinguished observationally by the presence of methane in the T dwarfs, but not the L dwarfs, which are too hot for methane to be stable. These observations use the IRS to observe several examples of each spectral subtype L0-L8, and T dwarfs of a variety of effective temperatures. These spectroscopic studes are important for 1) observing dust the atmospheres of these objects, which tells us about the chemical composition, temperature, and degree of convection on the object 2) observing molecular species in the atmospheres analogous to those observed in the Jovian planets of our own Solar System. The observations generally use the short-high and both low resolution modules.

Spitzer Space Telescope - Directors Discretionary Time Proposal #295

The First Spitzer Photometry of WZ Sge: A proposal to search for its circumbinary dust disk and to understand the brown dwarf secondary star

Principal Investigator: Steve Howell
Institution: NOAO

Technical Contact: Steve Howell, NOAO

Co-Investigators:
Jeff Adkins, Deer Valley High School
Tim Spuck, Oil City High School
Beth Thomas, Great Falls Public Schools
Don Hoard, Spitser Science Center
Carolyn Brinkworth, Spitser Science Center
David Ciardi, Michelson Science Center

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap
Hours Approved: 1.7

Abstract:
We propose to obtain the first IRAC photometry of WZ Sge. With these observations we will search for the circumbinary dust disk and gain a better understanding of the brown dwarf companion.

Spitzer Space Telescope - General Observer Proposal #40482

T dwarfs in the Pleiades

Principal Investigator: Richard Jameson
Institution: University of Leicester

Technical Contact: Richard Jameson, University of Leicester

Co-Investigators:
Sarah Casewell, University of Leicester
Paul Dobbie, AAO
Simon Hodgkin, University of Cambridge
Estelle Moraux, Universite Joseph Fourier
Matthew Burleigh, University of Leicester

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap
Hours Approved: 6.8

Abstract:
Using a deep CFHT survey at I and Z which was followed up by a deep UKIRT survey in the J band five years later, we have identified seven T dwarfs in the Pleiades. This was done using their I, Z and J colours and their proper motions. These are low mass (~10 Jupiter masses) brown dwarfs. We request Spitzer IRAC time to obtain principally 3.6 and 4.5 micron photometry for these objects, and also 5.8 and 8.0 micron photometry, albeit at poor S/N. These observations will be executed as a cluster observation and as a fixed single observation. These measurements will allow us to determine precise spectral types and also possibly gravity sensitive features and evidence for remnant dust disks. This will also provide, for the first time, data on the sequence of T dwarfs of known age (120 Myr).

Spitzer Space Telescope - General Observer Proposal #20435

Probing the Evolution of Brown Dwarf Disks

Principal Investigator: Ray Jayawardhana
Institution: University of Toronto

Technical Contact: Ray Jayawardhana, University of Toronto

Co-Investigators:
Gwendolyn Meeus, Astrophysikalisches Institut Potsdam, Germany
Christina Walker, University of St. Andrews, Scotland
Alexander Scholz, University of Toronto, Canada

Science Category: brown dwarfs/very low mass stars
Observing Modes: IrsStare MipsPhot
Hours Approved: 14.3

Abstract:
As the ranks of known isolated sub-stellar objects have swelled dramatically over the past five years, their origin and early evolution have become topics of widespread interest and fundamental significance. Recent observations have provided compelling evidence --in the form of infrared emission from dust and spectroscopic signatures of gas accretion-- that young brown dwarfs harbor circum(sub)stellar disks, just like low mass stars. Studies of these disks and their evolution could shed light on the origin of brown dwarfs themselves as well as the potential for planet formation around very low mass primaries. Here we propose to obtain IRS low-resolution spectra and MIPS photometry of all known brown dwarfs in the 5-Myr-old Upper Scorpius association, which represents the largest spectroscopically confirmed sample of young coeval sub-stellar objects. Combined with our near-infrared and (sub)millimeter observations from the ground, these Spitzer data will allow us to construct well constrained SEDs from about 1 micron all the way to 1 mm. We will derive important disk parameters and dust properties through model fits to the continuum SED and to the low-resolution spectra across the 10-micron silicate emission feature, and investigate such issues as disk geometry (flat v. flared), grain growth and processing and inner disk clearing. For the first time, our results will provide statistically significant constraints on the evolution of brown dwarf disks over the critical timescale of ~5 Myr, for meaningful comparison with the evolution of disks around higher mass stars over the same age range. We will estimate disk sizes and masses from the far-infrared and (sub)millimeter data, to help distinguish between different scenarios for brown dwarf origin. We will also evaluate the prospects for planet formation (from disk masses) and look for evidence of planetesimal evolution processes (grain growth, inner disk holes) around these brown dwarf primaries.

Spitzer Space Telescope - General Observer Proposal #20750

IRS Characterization of a Debris Disk around a 25 Myr M-type Star

Principal Investigator: Charles Lada
Institution: Harvard-Smithsonian Center for Astrophysics

Technical Contact: Charles Lada, Harvard-CfA

Co-Investigators:
Paula Teixeira, Harvard-Smithsonian Center for Astrophysics
James Muzerolle, University of Arizona
Kevin Luhman, Harvard-Smithsonian Center for Astrophysics
Erick Young, Steward Observatory, University of Arizona

Science Category: brown dwarfs/very low mass stars
Observing Modes: IrsStare
Hours Approved: 8.4

Abstract:
Spitzer IRAC and MIPS observations of the 25 Myr old stellar cluster NGC 2547 has provided us with an initial census of the disk population in the cluster. Only 5% show some excess emission in the IRAC bands suggestive of the presence of primordial or protoplanetary disks, although no excess emission is detected at near-infrared wavelengths for these sources. MIPS observations has provided us with the discovery of a late-type star with a considerable 24um excess emission. This suggests the star possesses a debris disk with an inner hole since negligible IRAC excess emission is measured. Spectra has identified this star as being of spectral type M4.5 and we have begun modeling the SED and estimate the disk mass. We wish to further study this particular disk with IRS to characterize its structure and composition, and ultimately, add to the scare observational knowledge on debris disks around late-type stars.

Spitzer Space Telescope - Archive Research Proposal #40645

Computing the Temperature Dependent Rovibrational Spectrum of Ammonia

Principal Investigator: Timothy Lee
Institution: NASA Ames Research Center

Technical Contact: Timothy Lee, NASA Ames Research Center

Co-Investigators:
David Schwenke, NASA Ames Research Center
Xinchuan Huang, NASA Ames Research Center

Science Category: brown dwarfs/very low mass stars
Dollars Approved: 71074.0

Abstract:
Molecules with large amplitude motions possess significant complexity in their rovibrational and purely rotational spectra. Because of this complexity, they are ideal molecules to be used to characterize the physical conditions of the celestial objects and galactic environments in which they are observed, which was noted more than two decades ago by Ho and Townes. The simplest and best characterized molecule with a large amplitude motion of interest in astronomy is ammonia. The available experimental data for even this molecule, however, is not sufficient to generate a synthetic spectrum that compares well with observations from the Spitzer Space Telescope of one of the coolest known T dwarfs Gl570D, and this is likely to be the case for any celestial environments above 400K. The IRS instrument on the Spitzer Space Telescope has already recorded spectra that cannot be well modeled and interpreted using the available experimental data for ammonia. In response to the urgent need for better line lists, including intensities, we propose to use the tools of theoretical spectroscopy, combined with refinement using the available experimental data, to obtain highly accurate line lists for ammonia and its isotopomers. Through the use of high accuracy electronic structure calculations, and refinement of the resulting potential energy surface (PES) with the available experimental data, Schwenke has already constructed highly accurate lists for all isotopomers of the water molecule. The accuracy of the resulting PES, transition energies, and intensities has been demonstrated by later spectroscopic studies. We propose to use a similar approach for ammonia. Our approach will be to use high-level electronic structure calculations to construct a highly accurate, isotope independent PES and dipole surface for the ammonia molecule. The resulting highly accurate PESs and dipole moment surfaces will then be used to solve the nuclear Schroedinger equation to generate the necessary line lists.

Spitzer Space Telescope - Directors Discretionary Time Proposal #281

IRAC Colors for T/Y Dwarf Candidate ULAS0034--00

Principal Investigator: Sandy Leggett
Institution: Joint Astronomy Centre Hilo Hawaii

Technical Contact: Sandy Leggett, Gemini Observatory

Science Category: Brown Dwarfs/Very Low Mass Stars
Observing Modes: IracMap
Hours Approved: 1.0

Abstract:
The first data releases (EDR and DR1) from the UKIRT Infrared Deep Sky Survey are now available. UKIDSS goes three magnitudes fainter than 2MASS, and should discover even cooler low-mass brown dwarfs than those currently known. Searches of the EDR and of the 0-2 hour RA range in DR1 have produced three spectroscopically confirmed T4-T6 dwarfs and one other dwarf that looks to be the seventh known later than T7, or cooler than 900K. This object, ULAS0034-00, appears to be very similar in the near-IR to a known T8 with Teff=700K. It may in fact be cooler, as the spectral absorption features in the near-IR are extremely strong at these temperatures, and little flux remains either to be absorbed or for use for spectral typing. Although bands of NH3 are expected to be seen at 600K, there is evidence that the abundance of NH3 is much lower than calculated, and so these features may not be seen until much cooler temperatures are reached. IRAC photometry will allow us to determine whether this object is significantly cooler than the known late T dwarfs, and is perhaps the prototype of the Y dwarfs. DDT time is requested so that these data can be obtained seven months earlier than would otherwise be possible in Cycle 4. The results will be important both for searches of the ongoing UKIRT survey, and for modelling the coolest dwarfs. It is possible that all 500-700K brown dwarfs will look the same in the near-IR, and can only be distinguished by Spitzer mid-IR observations.

Spitzer Space Telescope - General Observer Proposal #3431

An IRS Study of the Coolest T Dwarfs and the L-T Transition

Principal Investigator: Sandy Leggett
Institution: Joint Astronomy Centre Hilo Hawaii

Technical Contact: Sandy Leggett, Gemini Observatory

Co-Investigators:
Xiaohui Fan, Steward Observatory
Tom Geballe, Gemini Observatory
Dave Golimowski, Johns Hopkins University
Mark Marley, NASA Ames
Didier Saumon, Los Alamos National Laboratory

Science Category: brown dwarfs/very low mass stars
Observing Modes: IrsStare
Hours Approved: 38.8

Abstract:
Recent 1-5 micron studies of ultracool L and T dwarfs indicate that changes in the near-infrared spectra across the L-T transition are governed by complex cloud dynamics rather than by large changes in effective temperature. These studies also suggest that nonequilibrium chemistry in late-T dwarfs significantly affects the photospheric abundances of CO, CH4, and NH3, all of which influence the spectral energy distributions from 1 to 30 micron. A focused study of L-T transition and late-T dwarfs longward of 5 micron is crucial to understanding the agents that govern the dynamic and chemical processes in the atmospheres of these brown dwarfs. We request 38.8 hours of IRS time in Cycle 1 to study 7 late-L and early-T dwarfs and 7 late-T dwarfs. The size of our L-T transition sample matches that of the GTO "irs_lt-stars" study, but our sample includes late-L dwarfs with extremely blue and extremely red near-infrared colours. Our sample of late-T dwarfs is similar in size to that of the GTO mid- to late-T program, but our sample includes a possible low-gravity T dwarf with red near-infrared colours as well as the coolest known T dwarf with an effective temperature ~700 K. By combining the IRS data with our existing 0.8-2.5 micron spectra and 0.9-4.7 micron photometry, we will investigate the effects of grain condensation, nonequilibrium chemistry, and gravity on the atmospheres of these brown dwarfs. Our comprehensive data will allow us to constrain models of the transition from dusty red L dwarfs to clear blue T dwarfs, determine the prevalence and importance of nonequilibrium chemistry, and examine gravity (and hence mass) signatures in the spectra of these brown dwarfs.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40419

IRS Observations of Two Very Low Mass T Dwarfs

Principal Investigator: Sandy Leggett
Institution: Gemini Observatory

Technical Contact: Thomas Roellig, NASA Ames Research Center

Co-Investigators:
James Houck, Cornell University
Steve Warren, Imperial College London
Richard Jameson, University of Leicester
David Pinfield, University of Hertfordshire
Phil Lucas, University of Hertfordshire
Nicolas Lodieu, Instituto de Astrofisica de Canarias
Mark Marley, NASA Ames Research Center
Didier Saumon, Los Alamos National Laboratory
Michael Cushing, University of Arizona
Davy Kirkpatrick, IPAC
Greg Sloan, Cornell University
Amanda Mainzer, Jet Propulsion Laboratory
Jeff Van Cleve, Ball Aerospace
John Wilson, University of Virginia

Science Category: brown dwarfs/very low mass stars
Observing Modes: IrsStare
Hours Approved: 13.9

Abstract:
We request 13.9 hours of IRS GTO time to observe two recently discovered very low-mass T dwarfs, the early-T HN PegB and the very late-T ULAS J0034. As inferred from models, the two T dwarfs have similar masses of around 20 MJupiter, and similar gravities, but very different effective temperatures of Teff ~1100 K and 650 K for HN PegB and ULAS J0034, respectively. The warmer T dwarf is of special interest as models currently cannot reproduce the flux distributions of the early-T dwarfs. HN PegB is the only early-T dwarf that is observable with the IRS that is also a companion to a main sequence star, so that age and metallicity can be constrained. The cooler T dwarf is of special interest as it is the coolest T dwarf currently known. The IRS data will allow us to complete the spectral energy distributions of these key brown dwarfs, for which near-infrared and IRAC data are already available. This will in turn enable a better determination of the fundamental parameters Teff, gravity and metallicity, as well as allow a study of the clearing of the cloud decks in the early-T dwarf, and of the chemical mixing due to vertical transport in the atmosphere of the late-T dwarf. Constraining these parameters and processes will allow refinement of the mass and age determinations for these important dwarfs.

Spitzer Space Telescope - General Observer Proposal #40449

Target of Opportunity Observations of Extreme-T or Y Dwarfs Found in the UKIRT Infrared Deep Sky Survey

Principal Investigator: Sandy Leggett
Institution: Gemini Observatory

Technical Contact: Sandy Leggett, Gemini Observatory

Co-Investigators:
Mark Marley, NASA Ames
Didier Saumon, Los Alamos National Lab
Steve Warren, Imperial College London
David Pinfield, Herfordshire University
Ben Burningham, Hertfordshire University
Phil Lucas, Herfordshire University
Mark McCaughrean, Exeter University
Nicolas Lodieu, IAC Tenerife

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap IrsStare
Hours Approved: 10.0

Abstract:
We request 45 hours of Spitzer IRAC and IRS time for low-impact Target of Opportunity targets. The targets will be very-late T or Y dwarfs found in the UKIRT Infrared Deep Sky Survey (UKIDSS) over the next year. Candidate very cool dwarfs identified in UKIDSS will be confirmed and classified by near-infrared spectroscopy at Gemini Observatory. Dwarfs of type T8 or later (of which there are only two currently published) will be submitted for IRAC observations. The coolest of these, those estimated to have an effective temperature Teff of 700K or less, will be followed up with IRS first-order short-low spectroscopy. UKIDSS has already found the latest-type T dwarf to date in a search of a 190 square degree area, a T8.5 with Teff approximately 650K, and an estimated age and mass of 1Gyr and 20 Jupiter masses. Over the next year a further 800 square degree area will become available, and we anticipate obtaining IRAC images of around eight 500-800K dwarfs, and IRS spectroscopy of four 500-700K dwarfs. Measuring the complete energy distribution of this new cold low-mass extension to the sub-stellar sequence is important to do while we have Spitzer's full cryogenic capability.

Spitzer Space Telescope - General Observer Proposal #20795

Spitzer Observations of Substellar Companions

Principal Investigator: Patrick Lowrance
Institution: SSC/Caltech

Technical Contact: Patrick Lowrance, SSC/Caltech

Co-Investigators:
Adam Burgasser, American Museum of Natural History
J.Davy Kirkpatrick, IPAC

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap IrsPeakupImage MipsPhot
Hours Approved: 7.6

Abstract:
Within the last ten years, the study of substellar objects has achieved spectacular success and present day studies have shifted substellar studies toward fundamental questions such as formation, evolution, and fundamental properties. Harder-to-measure parameters such as age and mass can only be measured with substellar companions. Observations of brown dwarf companions as standards become critical to understanding differences in field dwarfs where such parameters are unknown. Spitzer observations of known substellar comanions can be used as standard observations for time to come. Using the known quanties of the primary, the measured colors at mid-IR wavelengths, one can derive bolometric corrections and apply these to the nearly 500 field brown dwarfs now known but have unknown luminosities. Then models can be updated with the SEDs we can derive for the bright companions. Only Spitzer can allow these types of observations for questionable faint objects to come.

Spitzer Space Telescope - General Observer Proposal #30298

A Search for Y Dwarf Companions to Nearby Stars and Brown Dwarfs

Principal Investigator: Kevin Luhman
Institution: Pennsylvania State University

Technical Contact: Kevin Luhman, Pennsylvania State University

Co-Investigators:
Brian Patten, Harvard-Smithsonian Center for Astrophysics
Mike Schuster, Harvard-Smithsonain Center for Astrophysics
Massimo Marengo, Harvard-Smithsonain Center for Astrophysics
Joe Hora, Harvard-Smithsonain Center for Astrophysics
Giovanni Fazio, Harvard-Smithsonain Center for Astrophysics
John Stauffer, Spitzer Science Center

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap
Hours Approved: 16.6

Abstract:
We propose to obtain IRAC images of a large sample of nearby stars and brown dwarfs that we observed with IRAC during the first year of Spitzer science operations. By combining the data at these two epochs, we will search for substellar companions through their common proper motions with the primaries. These observations will comprise the deepest survey to date for wide substellar companions to objects in the solar neighborhood, and should provide the best available opportunity for finding the brown dwarfs cooler than known T dwarfs, such as the as-of-yet-undiscovered Y dwarfs.

Spitzer Space Telescope - Directors Discretionary Time Proposal #50013

A Search for Y Dwarf Companions to Nearby Stars and Brown Dwarfs

Principal Investigator: Kevin Luhman
Institution: Pennsylvania State University

Technical Contact: Kevin Luhman, Pennsylvania State University

Co-Investigators:
Massimo Marengo, Harvard-Smithsonian Center for Astrophysics
John Stauffer, Spitzer Science Center
Brian Patten, Harvard-Smithsonian Center for Astrophysics
Michael Schuster, Harvard-Smithsonian Center for Astrophysics
Joe Hora, Harvard-Smithsonian Center for Astrophysics
Giovanni Fazio, Harvard-Smithsonian Center for Astrophysics

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap
Hours Approved: 9.3

Abstract:
We propose to obtain IRAC images of a large sample of nearby stars and brown dwarfs that we observed with IRAC during the first 3 years of the Spitzer mission. By combining the data at these two epochs, we will search for substellar companions through their common proper motions with the primaries. These observations will comprise the deepest survey to date for wide substellar companions to stars and brown dwarfs in the solar neighborhood, and should provide the best available opportunity for finding the brown dwarfs cooler than known T dwarfs, such as the as-of-yet-undiscovered Y dwarfs.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40076

High-resolution Spectroscopy of Bright L and T Dwarfs

Principal Investigator: Amanda Mainzer
Institution: Jet Propulsion Laboratory

Technical Contact: Thomas Roellig, NASA Ames Research Center

Co-Investigators:
James Houck, Cornell University
Michael Cushing, University of Arizona
Didier Saumon, Los Alamos National Laboratory

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap IrsStare
Hours Approved: 11.3

Abstract:
We propose to take IRS high-resolution spectra of three of the brightest known L and T dwarfs in order to learn more about the chemical composition and atmospheric structure of these spectral classes. This program will expand the successful initial exploratory R=600 observations we carried out as an adjunct to our larger "Dim Suns" GTO R=90 survey of M, L, and T dwarfs. We review the results of these initial exploratory observations and show how an expanded program of R=600 IRS spectroscopy can give us unique insights into the atmospheres of brown dwarfs. The abundance of ammonia, trace molecular species, the effects of non-equilibrium chemistry, and clouds can all be studied effectively with R=600 Spitzer spectroscopy. Additionally, we request low-resolution spectroscopy and IRAC photometry of the newly discovered brightest T dwarf in the Northern hemisphere, IPMS J0136+0933. We discuss how our experiences with our initial observations will lead to reduced systematic errors (particularly those due to rogue pixels and sky subtraction). This is a GTO proposal with the time to be charged to the IRS GTO time pool.

Spitzer Space Telescope - Theoretical Research Proposal #30140

The Role of Dust and Non-Equilibrium Chemistry in the Atmospheres of L and T Dwarfs as Constrained by Spitzer IRS and IRAC Observations

Principal Investigator: Mark Marley
Institution: NASA Ames Research Center

Technical Contact: Mark Marley, NASA Ames Research Center

Co-Investigators:
Didier Saumon, Los Alamos National Laboratory

Science Category: brown dwarfs/very low mass stars
Dollars Approved: 67246.0

Abstract:
We propose to instensively study the physical processes that can affect the mid-infrared spectra and colors of L- and T-type brown dwarfs as observed by Spitzer. In particular we will modify our current atmosphere structure and spectral models of these objects to understand the origin of the unexpected flattening seen at 8 to 10 microns in IRS spectra of mid L-type objects. This flattening is likely due to a larger abundance of small silicate grains in the L dwarf clouds than predicted by our model. By producing a large number of models with a variety of grain sizes and compositions (enstatite, forsterite, and possibly quartz, including both crystalline and amorphous phases) we expect to constrain the composition and vertical structure of L dwarf cloud layers. We will also explore the role of non-equilibrium chemistry driven by atmospheric mixing in affecting the abundances of CO and ammonia in late L and T dwarf atmospheres. Excess CO lowers the flux in IRAC band 2 below that predicted by models that assume equilibrium chemistry and makes cool brown dwarfs more difficult to detect than predicted by equilibriium models (an important point for surveys aiming at detecting T and Y dwarfs). Lower than expected ammonia abundances are apparent in the shape of the ammonia absorption feature seen in IRS spectra at 10 microns.

Spitzer Space Telescope - Theoretical Research Proposal #40140

Understanding L/T Transition Binaries and Y Dwarfs

Principal Investigator: Mark Marley
Institution: NASA Ames Research Center

Technical Contact: Mark Marley, NASA Ames Research Center

Co-Investigators:
Didier Saumon, Los Alamos National Laboratory

Science Category: brown dwarfs/very low mass stars
Dollars Approved: 73653.0

Abstract:
We propose two investigations that are directly relevant to understanding Spitzer observations of L- and T-type brown dwarfs. First, we will provide important new constraintson the currently unknown mechanism responsible for the rapid L to T dwarf transition. To do so we will study L/T binary pairs, for which there are abundant Spitzer and groundbased datasets. Each member of a pair has the same age and metallicity, but very different spectral properties owing to their vastly different iron and silicate cloud decks. We will find self-consistent pairs of models that fit the unresolved Spitzer IRAC and IRS data and the available resolved near-infrared photometry. These pairs of models, each with the same age and metallicity, but differing mass, effective temperature, and cloud properties, will provide new constraints on the nature of the L to T transition, which is the major outstanding issue in studies of brown dwarf atmospheres. Secondly, we will produce new models of very cool (Teff < 600 K) brown dwarfs to better understand the spectral signatures associated with the yet to be discovered Y dwarfs. Existing models in the literature have used outdated ammonia opacity datasets and do not account for the role of non-equilibrium chemistry, which we have demonstrated is crucial for understanding the slightly warmer T dwarfs. Our work will provide new predictions for the expected IRAC photometric signatures of Y dwarfs (which critically are fainter in Band 2 than generally expected) and will aid in the characterization of these objects when they are eventually discovered by various ongoing Spitzer (as foreground objects) or ground based surveys.

Spitzer Space Telescope - Directors Discretionary Time Proposal #244

Circumstellar Disks and Sub-Stellar Objects

Principal Investigator: Stanimir Metchev
Institution: UCLA

Technical Contact: Stanimir Metchev, UCLA

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap IrsStare MipsPhot MipsSed
Hours Approved: 7.0

Abstract:
This proposal consists of two parts related to the study of low-mass sub-stellar objects. In the first part, intend to obtain low-resolution IRS spectra and MIPS 50-160um data of a nearby young star surrounded by a newly-discovered debris disk, containing an embedded point source at 50 AU - a candidate planet. The system was discovered recently in the course of a ground- based adaptive optics survey for sub-stellar companions to young solar analogs. The AO images detect the disk in scattered light over 30-50 AU from the star. Through 5-38 micron IRS spectroscopy, sensitive to material at 1-20 AU from this sun-like star, I will be able to constrain the amount of dust and its composition at separations inaccessible through direct imaging. The MIPS 50-95um SED and 160um imaging data, combined with 24um and 70um GTO data, will constrain the temperature and amount of material in the resolved scattered light disk. The combination of imaging, spectroscopic and SED data over 1-160um will thus offer a unified picture of this intriguing system over orbital separations spanning the equivalents of the terrestrial and the ice giant zones in the Solar System. In the second part of the proposal, I will use 3-9 micron IRAC imaging to study the photospheres of newly-found candidate free-floating planetary-mass objects. I have identified such candidates from a positional and color cross-match between the SDSS and 2MASS surveys, aimed at discovering objects beyond the bottom of the T dwarf sequence, so-called Y dwarfs. All of the selected candidates are seen only in the SDSS z- and 2MASS J-bands, and thus have very red (i-z>3.0) optical and blue (J-Ks<1.0) near-IR colors, as is characteristic for late T dwarfs and as may also be expected for early Y dwarfs. If Y dwarfs are confirmed in the sample, their mid-IR colors of will constrain the abundances of the dominant molecular species (methane, ammonia, water) in their photospheres, and will allow a quantitative classification of this new spectral type.

Spitzer Space Telescope - General Observer Proposal #40489

The L/T Transition in the Photospheres of Young Sub-Stellar Companions

Principal Investigator: Stanimir Metchev
Institution: University of California, Los Angeles

Technical Contact: Stanimir Metchev, University of California, Los Angeles

Co-Investigators:
Kevin Luhman, Pennsylvania State Unniversity
Massimo Marengo, Harvard-Smithsonian Center for Astrophysics

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap IrsPeakupImage IrsStare
Hours Approved: 18.7

Abstract:
We propose 3.6-8.0 micron IRAC photometry and 5.5-22 micron low-resolution IRS spectroscopy and imaging of the sub-stellar companions to the ~0.3 Gyr-old stars HN Peg and HD 203030. The spectral types of the two secondaries span the critical transition between L and T dwarfs, which is characterized by a rapid sedimentation of dust and appearance of methane in sub-stellar photospheres. HN Peg B (T2.5) and HD 203030 B (L7.5) are the youngest known brown dwarfs at this transition, and present a unique opportunity to examine the role of surface gravity in the process. Both objects stand out from 1-10 Gyr L/T-transition dwarfs in the field because they are under-luminous in the near-IR compared to the expected luminosities for their ages. Probable reasons include: (1) a decrease in the effective temperature at the onset of methane formation at lower surface gravities in sub-stellar photospheres, or (2) a shift in the emitted flux from the near-IR to the mid-IR region of the SED of young brown dwarfs. The mid-IR is key for distinguishing between these two hypotheses because it contains several fundamental molecular transitions that create deep absorption bands in the SEDs of L and T dwarfs, and that are inaccessible for study from the ground. Our existing IRAC photometry of HN Peg B does reveal a 0.3-0.5 mag excess in its 3.6-8.0 micron SED. However, this excess is insufficient to account for the lower luminosity of HN Peg B, and indicates that both of the above hypotheses may hold true to certain degrees. With the present proposal we aim to independently confirm the gravity-dependent behavior of L/T-transition photospheres in the mid-IR through IRAC photometry of HD 203030 B. We will also seek the culprit for the mid-IR excess of HN Peg B through low resolution spectroscopy and peak-up imaging with IRS. To check for possible duplicity of HN Peg B as the reason for its excess, we request high angular resolution imaging with HST to complement our lower resolution Spitzer imaging.

Spitzer Space Telescope - General Observer Proposal #20803

Watching the Dust Settle: Disk Evolution in Young Brown Dwarfs

Principal Investigator: Subhanjoy Mohanty
Institution: Harvard-Smithsonian Center for Astrophysics

Technical Contact: Subhanjoy Mohanty, Harvard-CfA

Co-Investigators:
Antonella Natta, Osservatorio Astrofisico di Arcetri, INAF
Ilaria Pascucci, Steward Observatory, University of Arizona
Daniel Apai, Steward Observatory, University of Arizona
Jeroen Bouwman, Max-Planck-Institut fur Astronomie, Heidelberg
Kevin Luhman, Harvard-Smithsonian Center for Astrophysics

Science Category: brown dwarfs/very low mass stars
Observing Modes: IrsStare MipsPhot
Hours Approved: 8.8

Abstract:
We propose to investigate the evolution of brown dwarf disks beyond the initial disk-accretion phase, using Spitzer IRS and MIPS. Our sample comprises 29 young brown dwarfs in nearby star-forming regions and young clusters (rho Oph, Taurus, IC348, Cha I, R CrA, sig Ori and Upper Sco), spanning ages of <1 ? 5 Myr, and ranging in mass from the hydrogen-burning limit (80 MJup) down to nearly the planetary-mass domain (12 MJup). Extensive optical spectroscopy has revealed that most of the sources are either past, or nearing the end of, their main disk-accretion stage; nevertheless, they are still girdled by remaining disk material, as evinced by their observed infrared excesses. Stellar disks in such a transitional phase strongly manifest various evolutionary signatures, such as significant grain growth, gradual settling of dust to the disk midplane, annealing of amorphous silicates into crystalline ones, and the clearing of large inner holes by incipient planetesimal formation. Our goal is to explore whether similar processes occur in the sub-stellar domain as well. To this end, we will obtain: (1) low-resolution 5.2?14.5um spectra with Spitzer IRS, and (2) 24um photometry with MIPS. Combined with IRAC 3.6?8?m photometry already being acquired for our sample within large-scale GTO/GO surveys, our observations will allow us to determine the disk spectral energy distribution (SED) down to photospheric levels out to 24um, and precisely map out the shape of the 10um silicate emission feature. By comparing the SED and silicate feature to detailed disk radiative-transfer models and synthetic grain emission spectra, we will examine grain growth and composition, dust settling, and (possibly planetesimal-induced) gap formation in our brown dwarf disks, as a function of age and mass.

Spitzer Space Telescope - Directors Discretionary Time Proposal #248

Watching the Dust Settle: Disk Evolution in Young Brown Dwarfs

Principal Investigator: Subhanjoy Mohanty
Institution: Harvard-Smithsonian Center for Astrophysics

Technical Contact: Subhanjoy Mohanty, Harvard-CfA

Science Category: brown dwarfs/very low mass stars
Observing Modes: IrsStare MipsPhot
Hours Approved: 13.2

Abstract:
This program investigates the evolution of brown dwarf disks beyond the initial disk-accretion phase, using Spitzer IRS and MIPS. The sample comprises ~20 young brown dwarfs in nearby star-forming regions and young clusters (rho Oph, Taurus, IC348, Cha I, R CrA, sigma Ori and Upper Sco), spanning ages of <1 - 5 Myr, and ranging in mass from the hydrogen-burning limit (~80 M_Jup) down to nearly the planetary-mass domain (~12 M_Jup). Extensive optical spectroscopy has revealed that most of the sources are either past, or nearing the end of, their main disk-accretion stage; nevertheless, many are still girdled by remaining disk material, as evinced by their observed infrared excesses. Stellar disks in such a transitional phase manifest various evolutionary signatures, such as significant grain growth, gradual settling of dust to the disk mid-plane, processing of amorphous silicates into crystalline ones, and the clearing of large inner holes possibly due to planetesimal formation. To explore whether similar processes also occur in the sub-stellar domain, I shall obtain: (1) low-res 5.2-14.5um spectra with Spitzer IRS, and (2) 24um photometry with MIPS. By comparing the SED and 10um silicate emission to disk radiative-transfer models and synthetic grain emission spectra, I will examine dust composition, grain evolution, and (possibly planetesimal induced) gap-formation in brown dwarf disks, over the entire range of sub-stellar masses and beyond the accretion stage. Combined with data on sub-mm/mm emission from brown dwarf disks that we are currently obtaining, the Spitzer observations will also yield the first look at disk dispersal timescales in the brown dwarf regime.

Spitzer Space Telescope - General Observer Proposal #30717

Searching for very low mass companions around young brown dwarfs with IRAC

Principal Investigator: Subhanjoy Mohanty
Institution: Harvard-Smithsonian Center for Astrophysics

Technical Contact: Estelle Moraux, Laboratoire d'Astrophysique de Grenoble

Co-Investigators:
Estelle Moraux, Laboratoire d'Astrophysique de Grenoble, France
Jerome Bouvier, Laboratoire d'Astrophysique de Grenoble, France

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap
Hours Approved: 9.5

Abstract:
We propose to observe very low mass stars and brown dwarfs (M1 < 90Mjup) in young open clusters (Alpha Per and Blanco1; both with ~100 Myr) with IRAC to detect binary companions at any separation and with a mass ratio down to q~0.2. We will observe our targets in the 4 IRAC bands in order to determine their SED from NIR to MIR wavelengths and thus derive precise temperature and mass. Companions will then be identified by their excess in the IRAC 3.6 and 4.5 um bands, where our photometric accuracy is highest. Our approach is particularly well suited to detect 15-20 Mjup companions to 30-90 Mjup primaries.

Spitzer Space Telescope - General Observer Proposal #20386

Cores2Deeper - Deep imaging of Very Low Mass Objects discovered by c2d

Principal Investigator: Philip Myers
Institution: Smithsonian Astrophysical Observatory

Technical Contact: Philip Myers, Smithsonian Astrophysical Observatory

Co-Investigators:
Tyler Bourke, SAO
Neal Evans, U. Texas (Austin)
Tracy Huard, SAO
Tim Brooke, Caltech

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap MipsPhot
Hours Approved: 17.6

Abstract:
We propose a program of deep IRAC and MIPS 24 micron observations of a sample of cores from the c2d Legacy program. About half of these cores contain newly discovered low luminosity objects, which we call very low mass objects, or VLMOs. The VLMOs are candidate young stars, or even substellar objects. The first such example, L1014-IRS, shows several properties common to young stellar objects, including near-infrared excess suggestive of disk emission, a fan-shaped scattered light nebulosity suggestive of an outflow cavity, and a bipolar CO outflow of remarkably small extent (<1000 AU). The protostellar nature of the other candidates, for the most part, remains to be confirmed, which is the goal of this proposal. With observations that will be three times more sensitive than c2d, we will be able to determine accurate SEDs of the sample, search for faint extended nebulosity, and search for even fainter companions to the VLMOs, all important aspects to confirming their association with the cores and their low mass nature. We will also observe to equal sensitivity a sample of otherwise similar c2d cores which show no signs of associated VLMOs, in order to detect even fainter VLMOs, or place strict upper limits on the luminosity of any embedded source. For both the VLMOs and starless cores, the IRAC data will detect fainter background stars than c2d and enable the core density structure to be probed to small scales near the extinction peaks.

Spitzer Space Telescope - General Observer Proposal #3286

A search for planetary-mass brown dwarf companions to young M dwarfs in the Solar Neighbourhood

Principal Investigator: Iain Reid
Institution: STScI

Technical Contact: Iain Reid, STScI

Co-Investigators:
Peter Allen, University of Pennsylvania

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap
Hours Approved: 7.5

Abstract:
We propose to use the unparalleled mid-infrared sensitivity of the Spitzer Space Telescope to search for very low-mass brown dwarf companions to young M dwarfs in the immediate Solar Neighbourhood. Combining our 2MASS-based 20-parsec census of late-type dwarfs with the ROSAT bright source catalogue, we have identified 43 apparently single M dwarfs with activity levels comparable to similar stars in the Pleiades. Half of those stars are newly identified from our survey. Allowing for intrinsic dispersion in activity, all are likely to have ages of less than 500 Myrs, and therefore provide the best prospects of detecting planetary-mass brown dwarfs with temperatures approaching 400K. Surprisingly, only two stars are currently targeted by Spitzer. We propose to obtain deep IRAC images centred on the remaining 41 M dwarfs, with the aim of conducting an inventory of low luminosity companions at separations between 20 and 300 AU. These data will not only provide important information on the frequency and mass-ratio distribution of brown dwarf companions to late-type stars, but will also supply interesting constraints on the likely prevalence of planetary systems in the most common constituents of the Galactic disk.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40257

Accurate Effective Temperatures for M, L, and T Dwarfs

Principal Investigator: George Rieke
Institution: University of Arizona

Technical Contact: George Rieke, University of Arizona

Co-Investigators:
John Stansberry, University of Arizona
Zoltan Balog, University of Arizona

Science Category: brown dwarfs/very low mass stars
Observing Modes: MipsPhot
Hours Approved: 0.0

Abstract:
We will use a modified form of the infrared flux method to determine an accurate and consistent effective temperature scale for M, L, and T dwarfs. This work depends on the very accurate photometry available at 24 microns with MIPS and the consistent absolute calibration we have derived, good to 2% from 1 through 25 microns. The effective temperatures will provide a check of spectroscopic work by others (similarly to the use of the infrared flux method in studies of hotter stars). It should provide accurate temperatures across the L dwarf range where presently spectroscopic methods have difficulty because of the effects of atmospheric dust. Our method is also capable of identifying close binary pairs of brown dwarfs, and hence of testing the hypothesis that the peculiar behavior across the L/T transition is due to undetected binarity.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #56

Photometry of L and T Dwarfs and Late-Type M Stars

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: John Stansberry, The University of Arizona

Science Category: brown dwarfs/very low mass stars
Observing Modes: MipsPhot
Hours Approved: 15.0

Abstract:
L Dwarfs span the transition between stars and brown dwarfs, while T Dwarfs are all brown dwarfs. The MIPS program on these objects has two goals. The first is to obtain measurements of the 24 micron brightness of ~30-40 ‘L’ and ~8 ‘T’ Dwarfs, and of a comparable number of M stars with spectral types later than M5. To the extent possible, the targets will be selected to overlap with the IRAC and IRS programs. The photometry will provide the longest wavelength point in the spectra of these objects, in a region of the spectrum which is relatively uncomplicated compared to the visible through 15mum region, having only very broad absorptions by molecular hydrogen. As such, our photometry will serve as an anchor for determinations of the relationship between radius and luminosity. The photometry of late-type M stars will also be the first ever at such long wavelengths, and the data will also complement IRAC and IRS measurements which will be obtained for the same objects. The second goal emphasizes observations at 24mm (overlap with IRAC and IRS is not required, but is generally desirable). Since the 24mm luminosity of an L dwarf is only weakly dependent on its temperature, mass, or atmospheric parameters, flux measurements can be converted to distances in a straightforward way.

Spitzer Space Telescope - General Observer Proposal #20079

A Sensitive Search for Variability in Late L dwarfs: the Quest for Weather

Principal Investigator: John Stauffer
Institution: Spitzer Science Center

Technical Contact: John Stauffer, Spitzer Science Center

Co-Investigators:
Davy Kirkpatrick, IPAC/Caltech
Mark Marley, NASA Ames
David Charbonneau, Center for Astrophysics
Brian Patten, Smithsonian Astrophysical Observatory
Kevin Luhman, Center for Astrophysics
David Barrado, Lab. de Astrofisica Espacial y Fisica Fundamental
Sean Carey, Caltech
Patrick Lowrance, Caltech
Chris Gelino, Caltech
Tom Megeath, Smithsonian Astrophysical Observatory
Luisa Rebull, SSC/Caltech
Derek Buzasi, US Air Force Academy

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC IracMap
Hours Approved: 20.0

Abstract:
The near-infrared colors of L dwarfs cannot be explained without invoking the presence of clouds in their atmospheres. Throughout the L spectral sequence optical and infrared spectra show that important atomice and molecular species begin to disappear as major opacity sources as they condense into other, more complex forms. Such formation of condensate clouds also explains the increasingly red J-K colors of L dwarfs (~1.2 at early-L and up to 2.5 for late-L. The colors of T dwarfs, however, can only be explained if these condensate clouds are not present. Therefore, in the late L dwarf spectral range the cloud deck must begin its metamorphosis, and any azimuthal differences in the structure of the cloud decks would lead to photometric modulations as the brown dwarfs rotate. Various earlier studies have searched for this variability in the optical and near-infrared, but the low photometric accuracy of these studies has resulted in mixed results, without compelling evidence for any particular model of cloud dissipation. In this proposal we wish to re-explore this issue using the recently demonstrated milli-magnitude photometric accuracy of IRAC.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #118

MACHO Search

Principal Investigator: Michael Werner
Institution: JPL

Technical Contact: Hien Nguyen, Jet Propulsion Laboratory

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracMap MipsPhot
Hours Approved: 4.4

Abstract:
We will carry out deep imaging with IRAC (all bands) and MIPS (24um only) at the position of selected MACHO events in the LMC to search for cold objects which might be responsible for the magnification.

Spitzer Space Telescope - General Observer Proposal #20300

Photoevaporation and triggered star formation in the massive star forming region W5

Principal Investigator: Lori Allen
Institution: Smithsonian Astrophysical Observatory

Technical Contact: Lori Allen, Smithsonian Astrophysical Observatory

Co-Investigators:
Joseph Hora, Smithsonian Astrophysical Observatory
Luis Chavarria, Harvard-Smithsonian Center for Astrophysics
S. Thomas Megeath, Smithsonian Astrophysical Observatory
James Muzerolle, Steward Observatory
Erick Young, Steward Observatory
Chris Brunt, Five College Radio Astronomy Observatory

Science Category: massive stars
Observing Modes: IracMap MipsScan
Hours Approved: 23.6

Abstract:
We propose to image the massive star forming region W5 with IRAC and MIPS, to determine the importance of triggering in massive star forming regions. Spitzer is uniquely equipped to identify the young stars and protostars over a large area of sky through their infrared excess emission. Finding all the current sites of star formation in W5 will allow us to determine whether or not star formation on a large scale is dominated by triggering. Because of its geometry (and geography), W5 is an ideal candidate for a study of this kind.

Spitzer Space Telescope - General Observer Proposal #20034

Shocks and Outflows in Young Massive Stars: The R Mon / HH 39 System

Principal Investigator: Marc Audard
Institution: Columbia University

Technical Contact: Marc Audard, Columbia University

Co-Investigators:
Stephen Skinner, University of Colorado
Manuel Guedel, Paul Scherrer Institut
Thierry Lanz, University of Maryland
Frederik Paerels, Columbia University

Science Category: massive stars
Observing Modes: IracMap IrsMap IrsStare MipsPhot MipsSed
Hours Approved: 4.1

Abstract:
We propose to use Spitzer's sensitive imaging and spectroscopic capabilities to undertake a comprehensive infrared study of the massive young star R Mon and its associated Herbig-Haro object HH 39. We will reach unprecendented sensitivities with IRAC to search for mid-IR emission from R Mon's circumstellar disk, and from its powerful jets and outflow. We will obtain the first deep mid-IR image of the HH 39 complex located 7' North of R Mon with IRAC and MIPS. We will search for mid and far-IR emission from shocked material, similar to that recently detected by IRAC in HH 46/47. With IRS, we will obtain the first mid-IR spectra of R Mon's bipolar jet and of several emission knots in HH 39. We will also derive the low-resolution SED of R Mon with MIPS. Despite its spectacular nature, R Mon has received little attention in the mid-IR and was never observed by ISO. This short Spitzer proposal aims at studying in young massive stars the physical links between accretion disks, outflows and jets, and shocks in the associated HH objects. The latter can help us understand the importance of the mechanical energy input of young stars for the origin of turbulence in molecular clouds. The R Mon/HH 39 system is ideal to fulfill our goals.

Spitzer Space Telescope - General Observer Proposal #20778

A Young Stellar and Protostellar Census of Galactic Ultracompact HII Regions -- Exploring Massive Star Formation with MIPS and IRAC

Principal Investigator: Sean Carey
Institution: SSC

Technical Contact: Jeonghee Rho, Caltech

Co-Investigators:
Jeonghee Rho, Spitzer Science Center / Caltech
Peter Conti, JILA / University of Colorado
Paul Crowther, University of Sheffield
Alberto Noreiga-Crespo, Spitzer Science Center / Caltech

Science Category: massive stars
Observing Modes: IracMap MipsPhot MipsSed
Hours Approved: 13.0

Abstract:
We will map regions around 41 ultracompact HII (UCHII) regions from the radio selected Midcourse Space Experiment (MSX) sample of Crowther & Conti (2003) using IRAC and MIPS to (i) determine their embedded source contents; (ii) the multiplicity of high mass star formation and (iii) estimate the initial mass function of the sample. Our sample spans a range of UCHII morphology and Galactic environment. The proposed observations will detect all massive star formation ongoing in these objects and permit robust determination of the number of stars powering each UCHII, in contrast with previous mid-IR observations which were poorly spatially matched with radio observations. Deep imaging with IRAC will look for molecular line emission associated with shocked massive outflows, and MIPS observations will be critical to detect the earliest and most massive protostars and to construct the spectral energy distributions of the protostars. The data will be used to examine various theories of massive star formation and to examine the role of triggered star formation in these early massive objects.

Spitzer Space Telescope - General Observer Proposal #3594

Determining Wolf Rayet Wind Structure from IRS Spectra

Principal Investigator: Joseph Cassinelli
Institution: University of Wisconsin-Madison

Technical Contact: Joseph Cassinelli, University of Wisconsin-Madison

Co-Investigators:
Henny Lamers, Astronomical Institute, University of Utrecht
Richard Ignace, East Tennessee State University
Edward Churchwell, University of Wisconsin-Madison

Science Category: massive stars
Observing Modes: IrsStare
Hours Approved: 2.9

Abstract:
We propose obtaining IRS spectra of a selection of 8 single Wolf Rayet stars, of both WC and WN subclasses. By observing spectral lines over the broad range from 10 to 40 microns we will be able to study the density concentrations or "clumpiness'' of the winds of WR stars over a geometrically extended region. This is because IR-radiation of increasing wavelength, comes from increasingly higher layers in the wind. Knowing about the clumpiness is crucial for three reasons: 1. the mass loss rates of WR stars derived from observed spectra depends on the adopted clumping and the clumping seems to decrease with distance 2. clumpiness increases the possibility of photons to escape and so it influences the applicability of the current WR wind models that depend on multiscattering of the radiation field. 3. It has been discovered recently that the IR flux distributions (i.e. the spectral slope) of WR-stars depend in a systematic way on the spectral subclass from WC 4 to 7 and WN 4 to 7. The IRS spectra will provide an explanation of this. This will provide a basis for interpreting the IRAC colors of the hundreds of WR stars that are expected to be discovered in the GLIMPSE legacy survey of the Galactic plane.

Spitzer Space Telescope - General Observer Proposal #50167

Understanding the Dust Shells around Magellanic Cloud Red Supergiants

Principal Investigator: Geoffrey Clayton
Institution: Lousiana State University

Technical Contact: Geoffrey Clayton, Lousiana State University

Co-Investigators:
Karl Gordon, STScI
Ben Sugerman, Goucher College
Patrick Morris, California Institute of Technology
Phil Massey, Lowell Observatory
Michael Wolff, SSI
Doug Welch, McMaster University
Emily Levesque, University of Hawaii
Knut Olsen, NOAO
David Silva, Thirty Meter Telescope
Bertrand Plez, GRAAL, Univ Montpellier II
Barbara Ercolano, CfA

Science Category: massive stars
Observing Modes: IrsStare
Hours Approved: 5.5

Abstract:
It is both surprising and exciting to find that young galaxies at high redshift contain large dust masses. For galaxies at z>5, after only 1 Gyr, there has not been time for low-mass stars to have evolved to the AGB phase and produce dust. In such galaxies, Type II SNe and red supergiants (RSGs) may even dominate the dust production rate. It has long been known that RSG atmospheres produce dust, but little is known about it. So we are pursuing three parallel studies to better understand RSG dust. First, we are using optical spectra and JHK photometry to characterize the optical and near-IR extinction curves of the RSGs. Second, we are using the optical spectra combined with the 2MASS, IRAC and MIPS photometry to estimate the dust mass loss rates from Local Group RSGs as part of our archive program. In addition, we will use our Monte Carlo radiative transfer models to analyze the emission from dust in the circumstellar shells. Third, the final piece of the puzzle will be provided by obtaining new IRS spectra of LMC and SMC RSGs. We plan to use the IRS to make a systematic study of the dust properties in RSG shells in the LMC and SMC so that we can probe how they may vary with a large range of galactic metallicities. The intrinsic parameters of these stars have been well determined and, unlike Milky Way RSGs, their distances are well known. The existence of this precision dataset along with the availability of the high-sensitivity IRS on Spitzer will give us a unique opportunity to study the properties of dust in a large sample of RSGs. The new IRS spectra will be examined for emission features of PAHs, amorphous and crystalline silicates, and other materials, representing C-rich and O-rich dust dust produced around the star. The derived stellar SEDs and extinction curves will be combined with the IRAC and MIPS photometry and IRS spectra for use as inputs to our Monte Carlo codes which will be used to study the composition, size distributions and clumpiness of the dust.

Spitzer Space Telescope - General Observer Proposal #20154

Neon in WC and WO stars - testing nucleosynthesis and and massive star evolutionary predictions

Principal Investigator: Paul Crowther
Institution: University of Sheffield

Technical Contact: Pat Morris, Caltech

Co-Investigators:
John Hillier, Pittsburgh
Karel van der Hucht, SRON
Anthony Marston, ESTEC
Patrick Morris, IPAC
JD smith, Steward Observatory
Peredur Williams, University of Edinburgh
Allan Willis, University College London

Science Category: massive stars
Observing Modes: IrsStare
Hours Approved: 20.6

Abstract:
During the final stages of evolution of the most massive stars, identified with the Wolf-Rayet WC and WO subtypes, the abundance of Neon is predicted to undergo rapid, and substantial enhancements via nuclear processing in Helium-burning and alpha-capture reactions. At the onset of He-burning, 22Ne is predicted to increase by a factor of 100, and, later on, that of 20Ne by a further factor of 100 - yielding, respectively overall Ne/He enhancements of x10 (WC phase) and x100 (WO phase). Measurements of the Neon abundance at differing evolution stages provides the most definitive tests of such nucleosynthesis and of massive star evolution models. For WC and WO stars the only available lines for quantitative analysis occur in the mid-IR, via the fine-structure lines of [NeII]12.8 and [NeIII]15.5micron. We propose to obtain Spitzer IRS spectra of these lines in a sample of early-type WC stars (C/He = 0.1-0.5) and WO stars (C/He =1) to determine their Neon abundances and provide such tests of theory. Results to date for late-type WC stars suggest a discrepancy between observations and predictions. Spitzer is the only facility that can address this issue. Datasets will also cover other fine-structure transitions, notably [SIV]10.5 and [SIII]18.7, which will provide checks on the outer wind ionization balance, while [OIV] 25.9 will allow oxygen abundance determinations in a small sample of transition WN/C stars, which have C/He approx 0.001. O and Ne determinations for such stars will test abundance predictions from recent evolutionary models incorporating rotational mixing. He and C transitions formed in the inner, dense stellar wind, to allow a complete chemical analysis of the stars. Confirmation, or otherwise, of massive star evolution theory has implications for our understanding of young starbursts and the feedback of chemical, ionizing and kinetic enrichment into the ISM environments in galaxies.

Spitzer Space Telescope - General Observer Proposal #3337

Spitzer Observations of Newly Born Massive Stars in the W31 Cluster

Principal Investigator: Paul Crowther
Institution: University of Sheffield

Technical Contact: Paul Crowther, University of Sheffield

Co-Investigators:
Peter Conti, University of Colorado
Robert Blum, NOAO
Cassio Barbosa, IAG-USP, Sao Paulo
Patrick Morris, IPAC
Schuyler van Dyk, IPAC

Science Category: massive stars
Observing Modes: IracMap IrsStare
Hours Approved: 11.5

Abstract:
We propose IRS spectroscopy and a small IRAC map of individual young, massive stars in the giant HII region G10.2-0.3 within the W31 star forming region. Previous K-band observations by our team have revealed the presence of O stars, massive young stellar objects, ultra-compact HII regions, and featureless red sources, i.e. a snapshot of the earliest stages of massive star birth in a cluster. What is the reason for these differences among the stellar content of this cluster? To make progress on our understanding of these very early evolution stages it is imperative to tease out the properties of the underlying stars. We can obtain the integrated luminosities from our K-band photometry, but stellar temperatures are more challenging, requiring an analysis of nebular fine structure MIR lines of neon and sulfur for which IRS spectroscopic datasets are critical. We can also study how the dust grains, possible mantled by ices, have been processed in dense disks around these massive young stellar objects, providing additional insights into the role that dust plays in young star forming regions.

Spitzer Space Telescope - General Observer Proposal #30666

Mass Loss from Classical Cepheids and their Progenitors

Principal Investigator: Nancy Evans
Institution: Smithsonian Astrophysical Observatory

Technical Contact: Nancy Evans, Smithsonian Astrophysical Observatory

Co-Investigators:
Pauline Barmby, SAO
Massimo Marengo, SAO
Guiseppe Bono, INAF-Osservatorio Astronomico di Roma
Douglas Welch, McMaster University
Martino Romaniello, ESO

Science Category: massive stars
Observing Modes: IracMap MipsPhot
Hours Approved: 15.4

Abstract:
Classical Cepheid variable stars are primary extragalactic distance indicators, so accurately understanding and modeling them is vital. There remains a discrepancy between measured masses and masses from evolutionary and pulsation calculations, as evidenced by the recent results on Polaris. One possible explanation is mass loss. The current proposal is to observe a sample of Cepheids with Spitzer in order to determine whether mass loss is the explanation or whether adjustment to the physics of the computations is needed. The target list includes stars with a range in mass, luminosity, pulsation amplitude, and binary status, all of which could influence the level of mass loss. Spitzer observations have the spatial resolution to isolate any Cepheid emission from that of nearby stars or the background.Spectral energy distributions from Spitzer data should fully address the question of mass loss.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #106

IRAC's Potential to Solve the Microlensing Puzzle

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Brian Patten, Harvard-Smithsonian

Science Category: massive stars
Observing Modes: IracMap
Hours Approved: 1.6

Abstract:
We will image three LMC microlensing events with IRAC to probe the properties of the lensing object. We seek to address whether or not the lenses belong to some population of dwarf stars within the disk that are too cool to have been detected with conventional telescopes thus far or are part of a previously undetected disk-like structure in the halo of our galaxy. In most cases, the lens and source cannot be resolved individually, however, the presence of a cool lens can be inferred by way of an infrared excess.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #201

The Role of Photodissociation Regions in High Mass Star Formation

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Tom Megeath, Harvard, CfA

Science Category: massive stars
Observing Modes: IracMap
Hours Approved: 5.9

Abstract:
The evolution of high mass star formation regions is affected by the creation and evolution of photodissociation regions (PDRs), which are not present in the case of low mass star formation since the latter do not emit the necessary UV. In star forming regions like NGC 7538 and S252, high mass YSOs representing a second generation of star formation are often found embedded in PDRs. We would like to understand how the chemistry, composition, and structure of PDRs fit in to the overall puzzle of high mass star formation. To this end, we propose a program of high sensitivity IRAC imaging of the infrared emission from these diffuse regions. IRAC's spectral coverage, high sensitivity to extended IR emission, and good spatial resolution over large fields will allow us to obtain critical data on the dust populations in PDRs. In particular, three of IRAC's four bands include wavelengths of emission from PAHs, which strongly contribute to the heating of PDRs via photoelectric heating due to PAHs' highly efficient ionization by far-IR photons. PAHs are excellent diagnostics for probing the conditions in PDRs through spectral and spatial variations.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #202

Star Formation in Bright Rimmed Clouds

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Tom Megeath, Harvard, CfA

Science Category: massive stars
Observing Modes: IracMap MipsPhot
Hours Approved: 5.2

Abstract:
Bright-rimmed clouds (BRCs) contain dense molecular gas cores with at least one edge illuminated by a hot high-mass star, and as such they are good laboratories for the study of radiation-implosion driven star formation. The goal of this program is to obtain a complete census of protostars and young stars in a distance-limited sample of BRCs. The spatial distributions of the embedded protostars and young stars will be analyzed for signatures of sequential, or triggered, star formation. We plan to image a sample of 20 BRCs in the four IRAC bands and in the 24 micron band of MIPS. The sample is drawn from that of Sugitani et al. (1991, 1994) for BRCs within 1 kpc of the Sun. Since these sources are relatively compact, no mapping is required. The IRAC observations will consist of 5 dithered images centered on the source to encompass both the bright rim and the IRAS source contained within the core. The images will be obtained in the 12-sec HDR mode. MIPS photometry observations will be obtained at 24 microns, using an integration time at 24 microns of 10 seconds. The IRAC and MIPS observations each require about 9 minutes per source. The entire program will require a total time of approximately 6 hours.

Spitzer Space Telescope - General Observer Proposal #30734

Massive Star Clusters

Principal Investigator: Donald Figer
Institution: RIT

Technical Contact: Ben Davies, Rochester Institute of Technology

Co-Investigators:
Paco Najarro, CSIC
Rolf Kudritzki, University of Hawaii
John MacKenty, STScI
Massimo Robberto, STScI
Artemio Herrero, IAC
Michael Muno, UCLA
John Hillier, University of Pittsburgh
Annique Lenorzer, IAC

Science Category: Massive Stars
Observing Modes: IracMap
Hours Approved: 11.3

Abstract:
We are on the cusp of a revolution in massive star research triggered by 2MASS and Spitzer/GLIMPSE, and now is the ideal time to capitalize on these projects by performing the first survey of massive stars in young stellar clusters throughout the Galactic plane. A search of the 2MASS survey has produced over 450 newly-identified massive stellar cluster candidates which are hidden from our view at optical wavelengths due to extinction. We leverage the capabilities of Spitzer/IRAC to find and measure physical properties of the most massive stars in the best 86 targets in this sample. We propose a small program of 11 hours to image the candidate clusters in all four IRAC channels using a GLIMPSE-like observing strategy. With an analysis of these data, and those already existing through GLIMPSE, we expect to double the number of massive stars known in the Galaxy. This program addresses fundamental questions whose answers are basic requirements for studying many of the most important topics in Astrophysics: the slope to the initial mass function (IMF), an upper mass cutoff to the IMF, the formation and evolution of the most massive stars, the effects of massive stars on lower mass protostellar/protoplanetary systems, gamma-ray burst (GRB) progenitors, nature of the first stars in the Universe, chemical enrichment of the interstellar medium, Galactic gas dynamics, star formation in starbursts and merging galaxies (particularly in the early Universe). The proposed program is timely in that the young cluster targets have only recently been discovered and are going to be the subject of intense observations with HST and Chandra, as well as numerous approved and planned ground-based spectroscopic and radio observations. We have assembled an experienced team who have previously performed similar studies on much smaller samples, including the massive young clusters in the Galactic center, the Arches and Quintuplet cluster.

Spitzer Space Telescope - General Observer Proposal #3429

Mid-Infrared Spectroscopy of the Most Massive Stars

Principal Investigator: Donald Figer
Institution: STScI

Technical Contact: Donald Figer, RIT

Co-Investigators:
Paco Najarro, CSIC
Susan Stolovy, Spitzer Science Center

Science Category: massive stars
Observing Modes: IrsStare
Hours Approved: 4.2

Abstract:
The most massive star that can form is presently defined by observations of a class of very rare stars having inferred initial masses of ~200 solar masses. There are only a few such stars in the Galaxy, including the Pistol Star, FMM362, and LBV 1806-20, the first two being located near the Galactic center, and third located in the disk near W31. Each has only recently been identified as so massive within the past 10 years through the analysis of infrared observations, but they are otherwise too faint, due to extinction, to observe at shorter wavelengths. These stars appear to be very luminous (L>10^6.3 solar luminosities), "blue" (T>10000 K), and variable (delta K~1 mag.), and the Pistol Star has ejected 10 solar masses of material in the past 10000 years. In addition, these stars have near-infrared spectra similar to those of prototypical Luminous Blue Variables, i.e. Eta Car and AG Car. Given their apparent violation of the Humphries-Davidson limit, they are presumably in a short-lived phase of stellar evolution that is often associated with rapid mass-loss through episodic eruptions of their outer atmospheres. We propose to determine the physical properties of these stars and the velocity and ionization structure in their winds by using spectra obtained with the high resolution modes of the Infrared Spectrograph (IRS) on the Spitzer Space Telescope. The 10 to 40 micron wavelength region is ideally suited for accessing a variety of lines from transitions of hydrogen, helium, iron, silicon, sulfur, among others; indeed, through our models, we predict that sufficiently sensitive spectra will yield over 300 spectral lines. In addition, we predict that the mid-infrared continuum will be dominated by free-free emission generated in the thick winds associated with these stars, an effect that should be clearly detectable in the spectra.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #129

IRS Observations of Selected LBVs

Principal Investigator: Robert Gehrz
Institution: University of Minnesota

Technical Contact: Elisha Polomski, University of Minnesota

Science Category: massive stars
Observing Modes: IrsStare
Hours Approved: 0.7

Abstract:
Mid-IR spectroscopy with IRS will be used to assess the chemical composition and dynamics of the winds of selected luminous blue variable stars.

Spitzer Space Telescope - General Observer Proposal #3397

Wolf-Rayet stars in the central region of the Milky Way

Principal Investigator: Wolf-Rainer Hamann
Institution: University of Potsdam

Technical Contact: Wolf-Rainer Hamann, University of Potsdam

Co-Investigators:
Lidia Oskinova, University of Potsdam
Goetz Graefener, University of Potsdam
Hans Zinnecker, Astrophysikalisches Institut Potsdam

Science Category: massive stars
Observing Modes: IrsStare
Hours Approved: 2.8

Abstract:
We propose to take mid-IR spectra of two Wolf-Rayet stars in the inner part of our Galaxy, within 30pc projected distance from the central Black Hole. Massive stars dominate the central galactic region by their mass-loss and ionizing radiation. A quantitative analysis of this stellar inventory is essential for understanding the energy, momentum and mass budget, for instance with respect to the feeding of the central black hole. Our group developed a highly advanced model code for the expanding atmospheres of WR stars. Recently we extended the spectrum synthesis to IR wavelengths. These models will be applied for the analysis of the Spitzer IRS data. The proposed mid-IR observations will provide a wide spectral range with many lines which are needed to determine the stellar parameters, such as stellar luminosity, effective temperature, mass-loss rate and chemical composition. Near-IR spectra of the program stars are available and will augment the analysis. The capability of our code to reproduce the observed mid-IR spectrum of a WN star has been demonstrated. The two targets we selected are sufficiently isolated, while the Galactic center cluster is too crowded for the size of Spitzer's spectrograph slit. As estimated from the K-band spectra, one of the stars (WR102ka) is of very late subtype (WN9), while the other star (WR102c) has the early subtype WN6. Hence they represent different stages in the evolutionary sequence of massive stars, the late-WN just having entered the Wolf-Rayet phase and the early WN being further evolved. We expect that the parameters of massive stars in the inner galaxy differ from the usual Galactic population. One reason is that higher metallicity should lead to stronger mass-loss, which affects the stellar evolution. The Spitzer IRS, with its high sensitivity, provides a unique opportunity to study representative members of the stellar population in the vicinity of the Galactic center.

Spitzer Space Telescope - General Observer Proposal #20444

The nature of extremely young massive protostars found by ISO

Principal Investigator: Thomas Henning
Institution: Max-Planck-Institute for Astronomy

Technical Contact: Oliver Krause, University of Arizona

Co-Investigators:
Oliver Krause, Steward Observatory, University of Arizona
Stephan Birkmann, Max-Planck-Institute for Astronomy
Eric Young, Steward Observatory, University of Arizona
Dietrich Lemke, Max-Planck-Institute for Astronomy
Hendrik Linz, Max-Planck-Institute for Astronomy
Juergen Steinacker, Max-Planck-Institute for Astronomy

Science Category: massive stars
Observing Modes: IracMap MipsPhot MipsSed
Hours Approved: 12.4

Abstract:
Using the ISOPHOT 170 um Serendipity Survey (ISOSS) we have constructed a catalog of more than 50 very cold and massive molecular cloud cores. (Sub)millimeter continuum images of these cores at 450, 850 and 1200 um revealed a number of compact sources that show infall signatures in molecular line profiles and have no counterpart in deep near-infrared images. These objects are excellent candidates for collapsing cold and massive pre-stellar cores on the verge of becoming massive protostars or protoclusters. Sensitive mid- and far-infrared observations are urgently required to verify their suggested nature. We therefore ask for 12 hours of Spitzer observing time to perform a detailed study of 13 sources from our ISOSS sample: I) MIPS spectrophotometry of the energy distribution around 70 um will reliably constrain their temperture and density distribution. II) Deep MIPS 24 um and IRAC mapping will verify whether the objects are indeed pre-stellar and contain no deeply embedded mid-infrared sources. We will apply a multi-wavelength radiative transfer code to perform a full 3D modeling of the Spitzer data and exisiting (sub)mm measurements. The discovery of a genuine massive protostar during its initial phase of gravitational collapse would be a Spitzer breakthrough in the field of star formation.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #199

Dust Properties Along the Wolf-Rayet Evolutionary Sequence

Principal Investigator: James R. Houck
Institution: Cornell University

Technical Contact: Pat Morris, Caltech

Science Category: massive stars
Observing Modes: IracMap IrsMap IrsStare MipsPhot
Hours Approved: 11.0

Abstract:
Massive stars ending in the Wolf-Rayet (WR) phase of advanced core-burning may drive star formation and dramatically influence the energy budget, kinematics, and chemistry of active star forming environments in galaxies, in the cores of some active galaxies, and our Galactic Center where the massive star content is high. The dust properties of these environments are affected by production of oxygen- and carbon-rich dust during the WN, WC, and related Luminous Blue Variable phases. However, the dust and gas in the compact carbonaceous dust shells around WC-type stars, and in the extended nebula around WN type stars (the precursors to WCs) are poorly studied. In particular, no thermal IR spectroscopy of O-rich dust in nebulae around WN stars is available, but there are indications from ISO observations of WR galaxies that they may be strong contributors of crystalline silicates, a possibility also supported by the dust content of less-evolved LBV nebulae. WC dust spectra are limited to only the 5 brightest WC9-type stars (ISO), and several additional late WC's at much reduced spectral coverage (SCORE, 8-13 micron). We are pursuing spectroscopy of previously unobserved dusty WR stars, including four compact dusty WC-type stars, with high resolution and SL spectroscopy to analyze the dust grain properties and composition along the early-type to late-type WC sequence. We can address the debate on the ISM vs. circumstellar nature of the 6.3um aromatic band. We will also do high resolution spectroscopy of the WN central stars, employng non-LTE model atmospheres to demonstrate how the mid-infrared spectrum can be quantatively analyzed to derive the fundamental stellar and wind parameters, and spectrally map the surrounding ring nebulae at low resolution for first results on WN dust. We can use H2 detections (reported only at 2.12 microns in one nebula thus far) to constrain the formation mechanism and abundances, allowing us to test the hypothesis the WR nebulae are the principal contributors of H2 in galaxies.

Spitzer Space Telescope - Directors Discretionary Time Proposal #535

Early Science - Epsilon Aurigae

Principal Investigator: Steve Howell
Institution: National Optical Astronomical Observatory

Technical Contact: Steve Howell, National Optical Astronomical Observatory

Co-Investigators:
Don Hoard, SSC
Robert Stencel, Denver U.
Luisa Rebull, SSC
Ken Mighell, NOAO
Caer McCabe, SSC
Darryl Stanford, College of San Mateo
Dean Brumheller, College of San Mateo
Sally Seebode, San Mateo HIgh School
Tim Spuck, Oil City Area School District
Chelen Johnson, Breck School

Science Category: massive stars
Observing Modes: IracMap
Hours Approved: 0.1

Abstract:
Epsilon Aurigae is one of the most unusual and famous eclipsing binary stars in all of astronomy, the subject of studies since 1824 but still defying explanation. During Spitzer Cycle 6, Eps Aur will begin its 2-year eclipse. We propose a very modest 0.1 hour program to obtain the first Spitzer IRAC observations of Eps Aur before eclipse.

Spitzer Space Telescope - General Observer Proposal #3340

IR census of Be stars in clusters and their surrounding field

Principal Investigator: Anne-Marie Hubert
Institution: Observatoire de Paris-Meudon

Technical Contact: Anne-Marie Hubert, Observatoire de Paris-Meudon

Co-Investigators:
Coralie Neiner, Estec / ESA
Sacha Hony, Estec / ESA
Christophe Martayan, Observatoire de Paris-Meudon, France
Laurens Waters, University of Amsterdam, Netherlands

Science Category: massive stars
Observing Modes: IracMap
Hours Approved: 23.7

Abstract:
We propose to study the proportion of Be stars in clusters and the galactic field with IRAC, by detecting the IR excess due to the excretion disk around these stars. This will yield an unbiased sample of the Be-star population, including Be stars with small disks and late-type Be stars. The Be-star occurence compared to the properties of the clusters (age, rotation,...) will provide insight into the origin of the Be phenomenon and its role in the evolution of massive stars, which remains a mystery since the discovery of Be stars 140 years ago. IRAC is particularly well suited for such a study since the four IR bands of this camera corresponds to the ideal wavelength domain to detect IR excesses in Be stars and to distinguish them from other similar emission objects.

Spitzer Space Telescope - Directors Discretionary Time Proposal #249

Massive Star Formation Across our Galaxy and Beyond

Principal Investigator: Remy Indebetouw
Institution: University of Virginia

Technical Contact: Remy Indebetouw, University of Virginia

Science Category: massive stars
Observing Modes: IracMap MipsPhot MipsScan
Hours Approved: 9.1

Abstract:
Massive stars dominate the energetics and evolution of the visible universe through their ionizing radiation, winds, and supernova explosions. Despite significant recent progress in understanding low-mass star formation, high-mass star formation is still a mystery. I will survey star forming regions in the inner and outer Galaxy and the LMC, to discover the obscured stellar content, analyze the proto-cluster and protostellar luminosity function, and probe the radiation and gas physics in star forming regions. The resolution and sensitivity of Spitzer is allowing, for the first time, a relatively unconfused analysis of star forming regions in extremely diverse environments.

Spitzer Space Telescope - General Observer Proposal #30956

Hot gas and cool dust around B[e] Supergiants

Principal Investigator: Joel Kastner
Institution: Rochester Institute of Technology

Technical Contact: Joel Kastner, Rochester Institute of Technology

Co-Investigators:
Catherine Buchanan, RIT
Bill Forrest, University of Rochester
Ben Sargent, University of Rochester
Raghvendra Sahai, JPL

Science Category: Massive Stars
Observing Modes: IrsMap IrsStare
Hours Approved: 0.8

Abstract:
We propose a joint Chandra/ACIS and Spitzer/IRS survey of plasma and thermal dust emission from CI Cam and five other galactic B[e] supergiant systems that are bright mid-IR sources. The results will test the hypothesis that many such stars harbor quiescent, "CI Cam-like" X-ray sources, and that these sources may be intimately related to the presence of binary companions as well as to the dusty disks recently detected in IRS spectoscopy of B[e] supergiants. ACIS spectrscopy will establish the presence and strength of any Fe fluorescence line emission in these systems. In parallel, the proposed joint Spitzer IRS observations will provide the means to ascertain the origin and evolution of dusty disks around B[e] supergiants.

Spitzer Space Telescope - General Observer Proposal #30030

The Density Structure of O Star Winds

Principal Investigator: Thierry Lanz
Institution: University of Maryland

Technical Contact: Marc Audard, Columbia University

Co-Investigators:
Jean-Claude Bouret, Lab Astrophysique de Marseille
John Hillier, Univ Pittsburgh
Marc Audard, Columbia University

Science Category: Massive Stars
Observing Modes: IrsStare MipsPhot MipsSed
Hours Approved: 19.4

Abstract:
Because of their dense hypersonic winds, O stars have a great influence on their environment by the deposition of mechanical energy and momentum, as well as by their copious emission of ionizing photons. There is a mounting evidence that O stars have highly-structured winds, ranging from X-ray wind emission, line profile variability, and from detailed NLTE analyses of UV wind line profiles. Substantially reduced mass loss rates are derived from simple clumped wind models compared to the classical analyses performed with smooth, homogeneous wind models. Mid-infrared recombination lines and free-free continuum are particularly sensitive to the density at the base of flow and thus allow us to investigate the region where clumping is believed to be initiated. Moreover, the IR lines are not as sensitive to the wind ionization as UV lines. We propose therefore to obtain IRS high resolution spectroscopy and MIPS photometry of a sample of O dwarfs and supergiants to empirically characterize the density structure of O star winds, and derive robust estimates of the mass loss rates. Because the ionizing spectrum of O stars is very sensitive to the wind properties, the Spitzer data will be an essential step towards a reliable prediction of ionizing fluxes of massive stars.

Spitzer Space Telescope - General Observer Proposal #3185

The Rich and the Poor: Wolf-Rayet Star Populations in Different Chemical Environments

Principal Investigator: Claus Leitherer
Institution: Space Telescope Science Institute

Technical Contact: Claus Leitherer, Space Telescope Science Institute

Co-Investigators:
Luciana Bianchi, Johns Hopkins University
Daniel Devost, Cornell University
James Herald, Johns Hopkins University

Science Category: massive stars
Observing Modes: IrsStare
Hours Approved: 54.3

Abstract:
Wolf-Rayet stars are thought to be a late phase in the evolution of massive stars when the end products of nuclear burning are exposed on the stellar surface. The combination of high luminosities, peculiar chemical abundances, and strong stellar winds generate characteristic spectral signatures that make even few Wolf-Rayet stars detectable out to cosmological distances. Our goal is to document the stellar wind properties of a carefully selected sample of Wolf-Rayet stars, quantify the dependence of the wind parameters on the environment, and study the ramifications on the fields of stellar wind theory, stellar evolution, and stellar population synthesis. We propose to obtain IRS SH, SL, and LL spectroscopy of the complete WNE population in the SMC, together with a control sample in the Milky Way. The Milky Way sample is well studied at all relevant wavelengths, including the radio, and allows us to cross-calibrate the mid-IR data. The SMC sample, although small, is representative of the Wolf-Rayet content of low-luminosity starburst galaxies, such as I Zw 18. The mid-IR continuum will provide wind density parameters, such as mass-loss rate and homegeneity. The emission-line spectrum will be used to constrain the velocity field, the ionization balance, and the wind chemistry. The results of our study will allow us to address several astrophysical and cosmological issues: (i) Do the wind properties of Wolf-Rayet stars differ in metal-poor and metal-rich environments? (ii) Are mid-IR mass-loss rates consistent with other wavelengths, and/or do they support significant wind clumping? (iii) Are all low-metallicity Wolf-Rayet stars binary systems? (iv) Are the observed Wolf-Rayet properties consistent with those adopted in current stellar evolution models? (v) Can we rely on metal-poor Wolf-Rayet stars as tracers of massive stars in distant Lyman-break galaxies?

Spitzer Space Telescope - Archive Research Proposal #40126

Circumstellar dust around Red Supergiants in the Local Group: When Smoke Gets in Your Eyes

Principal Investigator: Philip Massey
Institution: Lowell Observatory

Technical Contact: Philip Massey, Lowell Observatory

Co-Investigators:
Geoff Clayton, Louisiana State University
Emily Levesque, University of Hawaii
Knut Olsen, National Optical Astronomy Observatory
David Silva, Thirty Meter Telescope
Bertrand Plez, GRAAL, Univ Montpellier II (France)
Karl Gordon, Steward Observatory
Ben Sugerman, Goucher College
Doug Welch, McMaster Univ (Canada)
Barbara Ercolano, Center for Astrophysics, Harvard

Science Category: massive stars
Dollars Approved: 80618.0

Abstract:
Red supergiants (RSGs) are a short, but critical stage in the lives of 10-40 Mo stars. They suffer significant mass loss (of order 10^-6 Mo/yr). This mass loss is most easily detected from the thermal emission of circumstellar dust. Our recent work has established for the first time that the dust mass loss rates scale nearly linearly with bolometric luminosity for Galactic stars, and we now wish to understand how this relationship scales with metallicity by examining archival data containing RSGs in various Local Group galaxies. Our 4-m and MMT 6.5-m optical spectroscopy, combined with MARCS model atmospheres, have allowed us to determine the physical properties of these stars; we now need to examine the IR data to determine mass-loss rates. We will also use this information to understand what fraction of the dust in these galaxies is due to RSGs. In addition, we will use the archival IRAC and MIPS data to determine what the temperatures are of the dust shells around these stars. When we are done, we will know a lot more about the mass loss process of this short-lived but important evolutionary stage. In addition, we will know about the dust properties, and will have increased our understanding of the dust enrichment of these galaxies.

Spitzer Space Telescope - General Observer Proposal #50777

Analyzing the Nature of B[e] Ejecta and Their Place in High-mass Star Evolution Using High Resolution IRS Spectra

Principal Investigator: Bruce McCollum
Institution: Spitzer Science Center

Technical Contact: Bruce McCollum, Spitzer Science Center

Co-Investigators:
Frederick Bruhweiler, CUA/IACS
Anthony Marston, ESA/ESAC
Ekaterina Verner, CUA/IACS

Science Category: massive stars
Observing Modes: IrsStare
Hours Approved: 16.4

Abstract:
B[e] stars encompass a variety of different objects of various putative evolutionary states. Most of them cannot consistently be placed into known evolutionary categories using standard ground-based classification diagnostics. Yet the higher-mass B[e] stars have been proposed as evolutionary stages in the poorly-understood sequence of late-stage high-mass star evolution. We have recently discovered using deep H-alpha imaging that a large fraction of B[e] stars show a variety of lobes and shells which imply past and ongoing major mass-loss episodes. The nature and implications of these episodes is not clear. IRS spectra along with our new analysis techniques offer multiple ways to clarify this and other B[e] characteristics. We shall obtain high S/N, high resolution spectra of several B[e] stars in order to model their temperatures, densities, and abundances using models we recently developed. Our techniques, for example, were applied to Eta Car and revealed the nature of its hidden binary companion. In addition, the spectra will reveal much about the nature of the dust in the envelopes. We shall also obtain off-star spectra of the ejecta in order to use established chemical clues to infer the physical conditions at the time of dust formation, which in other rapidly-evolving sorts of stars has successfully been used to show evolutionary linkages between objects which appear fundamentally different at present.

Spitzer Space Telescope - General Observer Proposal #30544

The Mass Loss Histories of Hot, Massive Stars Revealed by their Circumstellar Nebulae and Interactions With the ISM

Principal Investigator: Pat Morris
Institution: Spitzer Science Center

Technical Contact: Pat Morris, Caltech

Co-Investigators:
Anthony P. Marston, ESA/ESAC, Villafranca del Castillo
Jeronimo Bernard-Salas, Cornell University
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Schuyler van Dyk, Caltech/SSC
Karel van der Hucht, SRON Netherlands Inst for Space Research
Alberto Noriega-Crespo, Caltech/SSC
Rens Waters, University of Amsterdam
Peredur Williams, University of Edinburgh

Science Category: massive stars
Observing Modes: IracMap IrsMap IrsStare MipsPhot
Hours Approved: 30.1

Abstract:
We propose to obtain IRS spectroscopy and IRAC and MIPS imaging of prototype dusty nebulae around Population I Wolf-Rayet stars and hot supergiant progenitors in order to more fully characterize the physical and chemical properties of the dust and nebular gas, and their interactions with the ISM. The mass loss histories of these stars in their relatively short post-Main Sequence phases are not well understood, yet their influences on the dynamics and chemistry in galaxies are profound. We are especially interested in the questions of the thermal processing of the dust that can lead to significant contribution of crystalline silicate material to the ISM, in comparison to galaxies observed to have higher contributions that are ascribed to recent massive starburst activity. The composition of the dust, and nebular abundances are also important to resolving uncertain relationships between the transition phases off the Main Sequence, helping to constrain the evolutionary predictions and testing the latest stellar wind models. The Spitzer instruments are ideally suited to better establishing the physical and chemical roles that these massive nebular winds play in the Galactic medium, focusing on these representative objects which could not be previously studied in detail due to limitations in senstivity and spatial resolution.

Spitzer Space Telescope - General Observer Proposal #3189

The recent formation of massive stars in the Galactic Center region

Principal Investigator: Frederic Schuller
Institution: Max Planck Institut fuer Radioastronomie

Technical Contact: Frederic Schuller, MPIfR

Co-Investigators:
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Edward Polehampton, Max Planck Institut fuer Radioastronomie
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Alain Omont, Institut d'Astrophysique de Paris
Jean-Pierre Maillard, Institut d'Astrophysique de Paris
Andrea Moneti, Institut d'Astrophysique de Paris
Michel Perault, Paris Observatory, LERMA/LRA
Annie Zavagno, Marseille Observatory
Martin Burgdorf, Caltech / IPAC
Joris Blommaert, Leuven Observatory
Ian Glass, South African Astronomical Observatory

Science Category: massive stars
Observing Modes: IrsMap
Hours Approved: 18.8

Abstract:
Star formation activity is strikingly prominent and peculiar in the Central Molecular Zone (CMZ, abs(l) < 1.5 deg, abs(b) < 0.5 deg), as shown by the emission from giant molecular clouds, from the radio range (e.g. Guesten 1989, Bitran et al. 1997) to the infrared (Cox & Laureijs 1989, Launhardt et al. 2002). The Arches, the Quintuplet and the central helium star clusters, all within 30 pc of the central radio source Sgr A*, give further testimony that recent bursts of massive star formation have been occurring in the nuclear disk of the Galaxy. Up to now, most work on recent star formation in the CMZ has focused on these exceptional clusters near the center, or on the large complexes such as Sgr B2 and Sgr C, which are conspicuous due to their prominent radio emission. Using mid-infrared ISOGAL data, complemented by the MSX catalog, we have extracted a sample of 300 massive Young Stellar Object (YSO) candidates over the entire CMZ, including the apparently relatively quiet regions outside of these large complexes. We propose to make use of the spectro-imaging capabilities of the IRS instrument to ascertain the nature and derive bolometric luminosities for a subsample of these candidates. This sample is complete down to a 15 micron flux density of 140 mJy over a 0.1 sq. deg. area. The IRS data, complemented with present and future data in the infrared and radio ranges, will allow us to characterize the star formation activity in the exceptional environment of the Galactic Center in great detail, and to infer informations about the star formation in the cusps of other galaxies, including active galactic nuclei.

Spitzer Space Telescope - General Observer Proposal #3536

Massive O Stars and Disks in the Young Stellar Cluster NGC 6193

Principal Investigator: Stephen Skinner
Institution: Univ. of Colorado

Technical Contact: Stephen Skinner, Univ. of Colorado

Co-Investigators:
Augusto Damineli, Univ. of Sao Paulo
Francesco Palla, Arcetri Observatory
Svet Zhekov, Space Research Institute

Science Category: massive stars
Observing Modes: IracMap IrsStare MipsPhot
Hours Approved: 1.4

Abstract:
The young stellar cluster NGC 6193 lies at a distance of 1.3 kpc in the southern Ara OB1 association, with an estimated age of only 3 My. At this age, roughly half of the lower mass stars in the cluster are expected to be surrounded by disks. Lying at the cluster center are two massive O-type stars (HD 150135 and HD 150136), separated by only 10 arc seconds. Their strong winds and UV radiation fields have very likely affected disk evolution in the surrounding low-mass pre-main sequence population. HD 150136 is a remarkable O5V + O6 binary with a short 2.7 day period, and shows unmistakable wind-shock signatures at both radio and X-ray wavelengths. We propose to undertake the first mid-IR study of NGC 6193 and its central O stars with Spitzer. IRAC and MIPS images will identify those objects that are still surrounded by disks, providing information on disk lifetimes and disk properties in the harsh O-star environment. IRS spectra will yield information on the mass-loss properties of the central O stars that is needed to undertake wind-shock modelling of existing Chandra X-ray spectra.

Spitzer Space Telescope - General Observer Proposal #3603

Massive Protostars Traced by Methanol Masers

Principal Investigator: Stephen Skinner
Institution: Univ. of Colorado

Technical Contact: Stephen Skinner, Univ. of Colorado

Co-Investigators:
Manuel Guedel, Paul Scherrer Institute

Science Category: massive stars
Observing Modes: IracMap
Hours Approved: 1.3

Abstract:
The formation of massive stars occurs in obscured regions that are not accessible to optical studies. Radio continuum observations can probe the environments of massive protostars if the central object is sufficiently evolved to ionize its surroundings and produce a detectable compact or ultra-compact HII region (UCHII). However, at earlier evolutionary stages, radio continuum emission may not be detected and other tracers are needed. One such tracer is methanol masers, which are commonly detected in massive star-forming regions even in the absence of UCHII regions. We propose to observe five massive protostars that are traced by methanol masers. Four of these lack radio-detectable UCHII regions and are thought to be extremely young. We will use the high IRAC sensitivity and Spitzer's excellent pointing accuracy to determine if mid-IR sources are located at or near the methanol maser positions. These observations will provide observational constraints on the poorly understood process of methanol maser formation, and will test the idea that such masers are formed in protostellar disks. In addition, we will obtain information on the mid-IR properties of numerous lower mass pre-main sequence stars located near our massive protostar targets, as well as Herbig-Haro objects.

Spitzer Space Telescope - General Observer Proposal #30472

The Infrared Light Echo of V838 Monoceritis

Principal Investigator: Kate Su
Institution: The University of Arizona

Technical Contact: Kate Su, The University of Arizona

Co-Investigators:
Karl Misselt, Steward Observatory
Dipankar Banerjee, Physical Research Laboratory
Nagarhalli Ashok, Physical Research Laboratory
Alon Retter, Penn State University

Science Category: massive stars
Observing Modes: IracMap IrsMap IrsStare MipsScan
Hours Approved: 9.5

Abstract:
We propose follow-up observations of the extremely interesting object V838 Monocerotis (V838 Mon). V838 Mon underwent a powerful nova-like eruption in 2002 and has been the object of intensive study ever since. A spectacular light echo was observed following the outburst and subsequent observations revealed a rapid evolution of V838 Mon with time. Our previous Spitzer observations have revealed an infrared light echo well correlated with the optical echo. In addition, we have discovered an unresolved hot dust component, perhaps representing material newly formed in the recent outburst. We propose to continue and expand our observations of V838 Mon to follow the time evolution of the infrared light echo, the unresolved hot dust, and constrain the environment and nature (models) of the V838 Mon phenomena.

Spitzer Space Telescope - General Observer Proposal #41024

NGC 3576: Spontaneous or Triggered Formation of a Giant HII Region

Principal Investigator: Leisa Townsley
Institution: Penn State U.

Technical Contact: Leisa Townsley, Penn State U.

Co-Investigators:
Remy Indebetouw, U. Virginia
Patrick Broos, Penn State Univ.
Eric Feigelson, Penn State Univ.

Science Category: massive stars
Observing Modes: IracMap
Hours Approved: 3.9

Abstract:
Our understanding of massive star formation is uncertain at all levels, from individual stars to massive stellar clusters to OB associations. Our first Chandra observation of the Galactic giant HII region NGC 3576 addressed one example of the first of these problems: because hard X-rays penetrate even very large columns of obscuring material, we were able to pinpoint massive, young, embedded stars that remained undetected even at 3.5 microns, solving the mystery of NGC 3576's missing ionizing sources. With a new ACIS-I pointing and the first Spitzer observation of this target, we will address the second two of these problems: how massive clusters form and how they are related to the formation and evolution of the larger-scale, unbound populations known as OB associations.

Spitzer Space Telescope - General Observer Proposal #20819

Two Great Observatories Reveal the Dynamical Mass Segregation in a Massive Star-Forming Cluster

Principal Investigator: Masahiro Tsujimoto
Institution: Pennsylvania State University

Technical Contact: Masahiro Tsujimoto, Pennsylvania State University

Co-Investigators:
Robert Benjamin, U. Wisconsin
Daisuke Baba, Nagoya U.
Eric Feigelson, Pennsylvania State U.
Konstantin Getman, Pennsylvania State U.
Patrick Broos, Pennsylvania State U.
Takahiro Nagayama, Kyoto University
Yoshiaki Hyodo, Kyoto University

Science Category: massive stars
Observing Modes: IracMap
Hours Approved: 0.2

Abstract:
We propose a joint Chardra/ACIS (75ks) - Spitzer/IRAC (10 minutes) observation of RCW36, a very young (2-3Myr) massive star-forming cluster that shows a hint of dynamical mass segregation in our NIR observation. This program aims to construct the mass-stratified radial profiles of stellar surface number density in the cluster in order to examine if the dynamical segregation is operating. The proposed Chandra and Spitzer observations are necessary to establish cluster membership among heavily contaminated NIR sources in our existing catalog. This will allow us to test the persence of dynamical mass segregation in this young cluster, giving a better understanding of cluster evolution.

Spitzer Space Telescope - Archive Research Proposal #20574

A GLIMPSE at Hidden Wolf-Rayet Stars in the Galaxy

Principal Investigator: Schuyler Van Dyk
Institution: Spitzer Science Center

Technical Contact: Schuyler Van Dyk, Spitzer Science Center

Co-Investigators:
Anthony Marston, ESTEC/ESA
Patrick Morris, IPAC
J.D. Smith, University of Arizona

Science Category: massive stars
Dollars Approved: 66315.0

Abstract:
Massive stars have an unparalleled effect on galaxy evolution, since their strong stellar winds and the inevitable supernovae input energy and chemical elements into the interstellar medium. O-type stars are thought to evolve through the red supergiant and luminous blue variable phases to become H-poor Wolf-Rayet (WR) stars, before explosion. Due to their high luminosity, the presence of WR stars can be detected in the integrated spectra of galaxies, and the short duration of this phase of massive stellar evolution makes WR stars excellent probes of very recent star formation, metallicity, and the initial mass function in the nearby Universe. Unfortunately, the number of WR stars in the Milky Way is deficient by factors of 4 to 10, depending on the models, and as a result we know little about the total massive star formation and the fate of massive stellar evolution in our own Galaxy. The culprit is the rapid increase with distance of the line-of-sight extinction, due to dust in the Galactic Plane, where most WR stars are located. Detecting new WR stars is greatly alleviated in the infrared, where extinction is substantially lower. For this reason, we will analyze the combination of point source extractions from the GLIMPSE Legacy and 2MASS surveys, since this merging of the mid- and near-infrared provides a powerful means of identifying a significant number of hidden WR stars in the Plane.

Spitzer Space Telescope - Archive Research Proposal #40240

Galactic Evolved Massive Stars Survey (GEMSS)

Principal Investigator: Schuyler Van Dyk
Institution: Spitzer Science Center

Technical Contact: Schuyler Van Dyk, Spitzer Science Center

Co-Investigators:
Patrick W. Morris, NHSC/Caltech

Science Category: massive stars
Dollars Approved: 87378.0

Abstract:
Massive stars have an unparalleled effect on galaxy evolution, since their strong stellar winds and the inevitable supernovae input energy and chemical elements into the interstellar medium. O-type stars are thought to evolve through, possibly the red supergiant phase, and the luminous blue variable phase to become H-poor Wolf-Rayet (WR) stars, before explosion. Due to their high luminosity, the presence of WRs can be detected in the integrated spectra of galaxies, and the short duration of these post-main-sequence evolutionary phases makes WRs, in particular, excellent probes of very recent star formation, metallicity, and the initial mass function in the nearby Universe. Unfortunately, the number of known WRs in the Milky Way is deficient by 4 to 10 times, depending on the models, and as a result we know relatively little about the total massive star formation and the fate of massive stars in our own Galaxy. This is due to the rapid increase with distance of the line-of-sight extinction, due to dust in the Galactic Plane, where evolved massive stars are located and hidden. Detecting new evolved massive stars is greatly enhanced in the infrared, where extinction is substantially lower. Therefore, we wish to continue a successful archival project, where we will merge 2MASS with the data products from the Spitzer Legacy programs that observed in the Galactic Plane (GLIMPSE, GLIMPSE-II, GLIMPSE-3D, MIPSGAL, MIPSGAL-II). This provides a powerful means of identifying hidden, evolved massive stars in the Plane. We have already discovered about 200 such stars, including 21 previously unknown WRs, based on the merged near-IR/mid-IR color space, as a result of our Cycle-2 archival program.

Spitzer Space Telescope - General Observer Proposal #3528

IRAC and MIPS Imaging of High Mass Outlfows: Pobing the Role of Accretion and Clustering in Massive Star Formation

Principal Investigator: Qizhou Zhang
Institution: Smithsonian Astrophysical Observatory

Technical Contact: Qizhou Zhang, Smithsonian Astrophysical Observatory

Co-Investigators:
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Henrik Beuther, SAO
Tirupati K. Sridharan, SAO
Debra A. Shepherd, NRAO
Leonardo Testi, Osservatorio Astrofisico di Arcetri, Italy
Christopher G. De Pree, Department of Physics and Astronomy, Agnes Scott C

Science Category: massive stars
Observing Modes: IracMap MipsPhot
Hours Approved: 10.7

Abstract:
The research on massive star formation has advanced significant over the last decade via ground-based observations at the near-infrared and mm wavelengths. However, the important mid-infrared regime has been largely neglected. We propose to observe eight carefully selected regions of massive star formation, which have been studied extensively with mm-interferometers, with the IRAC and MIPS cameras to study the protostellar cluster and outflow properties. We will 1.) study outflow collimation using the highly excited CO fundamental band and compare the collimation with better understood low-mass outflows; 2) identify the outflow powering sources and derive their mid-infrared fluxes and luminosities. Correlations of these properties with the outflow properties derived from mm-interferometer observations will reveal whether massive outflows are scaled-up versions of their low-mass counterparts. 3.) observe the cluster properties down to the hydrogen-burning limit to study how much clustering affects the massive star-formation process. This proposal will allow us to address a highly controversial question: whether high-mass stars form via accretion processes similar to low-mass stars, or whether they form via collisional agglomeration of lower mass stars.

Spitzer Space Telescope - General Observer Proposal #20581

Infrared studies of V838 Mon and V4332 Sgr - a new class of nova-like variables.

Principal Investigator: Nagarhalli Ashok
Institution: Physical Research Laboratory

Technical Contact: Kate Su, The University of Arizona

Co-Investigators:
Kate Su, Steward Observatory,Arizona
Dipankar Banerjee, Physical Research Lab.,India
Karl Misselt, Steward Observatory,Arizona

Science Category: evolved stars/pn/sne
Observing Modes: IracMap IrsMap IrsStare MipsPhot MipsScan MipsSed
Hours Approved: 5.6

Abstract:
Based on encouraging results that we have obtained with Spitzer Cycle 1 observations, we propose to extend our studies of the extremely interesting objects V838 Mon and V4332 Sgr. These objects, which had powerful nova-like outbursts in the recent past, are being recognized as a new class of eruptive variables. Our recent work on them in the optical and near-infrared have yielded several exciting results on them. These have given valuable insights into the nature of their circumstellar environment. However, while much has been learned about them, the cause of their mysterious outbursts is not a completely resolved issue. Our Spitzer observations detects the presence of extended nebulosity around V838 Mon. We show that while a part of this nebulosity could be the IR equivalent of the optical light echo, a significant part of it could be due to intrinsic emission from extended cold dust that surrounds the object. We propose observations that have the potential to (i) establish the origin and location of the dust causing the nebulosity (ii) study whether VMon-type objects have more than one outburst (iii) attempt to establish whether V838 Mon has a hot B type companion as suggested by the optical data and (iv) make the first study of the evolution of the light echo in the mid/far infrared in case the extended nebulosity around V838 Mon is basically a light-echo. Our proposed studies of V4332 Sgr will monitor the evolution of an object which is shown to display significant short-term photometric and spectroscopic changes.

Spitzer Space Telescope - General Observer Proposal #3242

STUDY OF A NEW CLASS OF NOVA-LIKE VARIABLES

Principal Investigator: Nagarhalli Ashok
Institution: Physical Research Laboratory

Technical Contact: Kate Su, The University of Arizona

Co-Investigators:
Kate Su, Steward Observatory, University of Arizona
Dipankar Banerjee, Physical Research Laboratory, India
Karl Misselt, Steward Observatory, University of Arizona

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare MipsPhot
Hours Approved: 4.4

Abstract:
There have recently been instances of nova-like explosions on two stars viz. V4332 Sgr and V838 Mon which have evoked keen and sustained interest in a large segment of the astronomical community. This interest has been heightened by the spectacular and rare light echo seen around V838 Mon. Both these objects - for which we have proposed the name quasi-novae - have displayed outburst properties which are significantly different from other known classes of eruptive variables like classical novae, symbiotic novae or born-gain AGB stars. Though the cause for their outburst is poorly understood at present, it is being recognized that the mechanism involved could be fundamentally different from conventional scenarios for classical novae eruptions. Thus there is an imperative need to study these objects in greater detail. Available data on them, as elaborated in the science case, shows a richness in their optical and near-IR spectra that is truly exceptional. We wish to study these objects further in the mid and far-IR regime. Such a study will help to get better insights into the cool circumstellar environment of this new class of objects and understand the nature of their outburst better. The proposed objects have already yielded very interesting optical and near-IR results so far. We anticipate - with a fair deal of conviction - that mid/far-IR studies will yield equally striking results. The Spitzer Space Telescope provides a unique opportunity - that does not come often - for carrying out such studies.

Spitzer Space Telescope - General Observer Proposal #20100

Infrared studies of the Helium nova V445 Puppis.

Principal Investigator: Dipankar Banerjee
Institution: Physical Research Laboratory

Technical Contact: Kate Su, The University of Arizona

Co-Investigators:
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N.M. Ashok, Physical. Research Lab., India
R.D. Gehrz, University of Minnesota
A. Henden, US Naval Obs'tory, Flagstaff
D.K. Lynch, The Aerospace Corporation, LA
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R.J. Rudy, The Aerospace Corporation, LA
S. Starrfield, Arizona State University
W.P Varricatt, Joint Astronomy Centre, Hawaii
R.M. Wagner, Large Binocular Telescope Observatory
C.E. Woodward, University of Minnesota

Science Category: evolved stars/pn/sne
Observing Modes: IracMap IrsStare MipsPhot
Hours Approved: 2.7

Abstract:
V445 Puppis, which erupted in a nova-like outburst in Dec. 2000, could well be the first, observed example of a "Helium nova". A classical nova eruption occurs on the surface of white-dwarf (WD) due to a thermo-nuclear runaway in the matter accreted by the WD from its companion main sequence star. Since this material is H rich, the outburst spectrum is expected to be rich in H lines in the optical and near-IR regions. Such H lines are invariably observed in novae spectra. However, V445 Puppis showed no sign of any H lines in the optical or near-IR spectra obtained after outburst and also in spectra obtained very recently. Instead it shows an unusual enrichment of Helium and Carbon spectral features. The object defies classification in known categories of eruptive variables and appears to be a potential Helium nova candidate. A "Helium nova" outburst had been predicted to occur when the accreted matter on the WD was Helium rich and appropriate physical conditions prevailed. But such a theoretical prediction had no observable counterpart till the outburst of V445 Puppis. Now, several theoretical studies, which have modelled the low outburst-amplitude observed in V445 Pup and also its slowly-declining light curve, indicate that it has strong potential as a genuine He nova candidate. Our proposed Spitzer observations will (i) study the properties of the thick dust shell that enshrouds V445 Pup. A significant part of the object's emission is in the infrared (ii) explore its spectra in the mid-IR and compare it with spectra of classical novae to see the differences between them. Such spectra, given the nature of V445 Pup, will have the potential to yield new/unanticipated results (iii) estimate physical properties like temperature, electron density etc. of the object's environment based on its spectra and (iv) try to detect the expanding nova shell from the 2000 outburst whose detection in the optical has been reported recently.

Spitzer Space Telescope - Directors Discretionary Time Proposal #230

Follow-up observations to the SST discovery of dust emission from SN 2002hh in NGC 6946

Principal Investigator: Michael Barlow
Institution: University College London

Technical Contact: Michael Barlow, University College London

Co-Investigators:
Janet Bowey, University College London
Geoffrey Clayton, Louisiana State University
Martin Cohen, University of California, Berkeley
Ethan Deneault, Clemson University
Joanna Fabbri, University College London
Tim Gledhill, University of Hertfordshire
Karl Gordon, Steward Observatory, University of Arizona
Margaret Meixner, Space Telescope Science Institute
Nino Panagia, Space Telescope Science Institute
Angela Speck, University of Missouri
Ben Sugerman, Space Telescope Science Institute
Alexander Tielens, University of Groningen
Douglas Welch, McMaster University
Michael Wolff, Space Science Institute, University of Colorado
Albert Zijlstra, UMIST, Manchester

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare MipsPhot
Hours Approved: 1.3

Abstract:
On September 6th we reported (Barlow et al.; IAUC 8400) the 3.6--8.0-um detection of the Type~II supernova SN 2002hh (located in the face-on spiral galaxy NGC 6946 at a distance of 6~Mpc), in archival Spitzer Space Telescope (SST) SINGS Legacy IRAC images taken on June 10.76 2004, when the 8.0-um flux of the supernova was 20.0 mJy. Since then we have also measured its flux in a SINGS Legacy MIPS 24-um image, taken one month after the IRAC data, which became available this week. SN 2002hh's IRAC+MIPS energy distribution can be fit by a 300K blackbody. Its equivalent blackbody emission radius of 1x10^17 cm is too large for the emitting dust to have been freshly condensed in the supernova (SN) ejecta, so it appears that the dust may have been formed and ejected in an earlier stage of evolution of the massive progenitor star and flash heated by the SN event. Gemini-N Director's Discretionary Time has been awarded to us this week for high angular resolution 3-20-um observations of SN 2002hh, to be be carried out in the next few weeks. We have also submitted a request for HST DD Time, with the aim of obtaining high angular resolution observations of SN 2002hh and its surrounds at optical and near-IR wavelengths, using the ACS and NICMOS (PI: B. Sugerman). Here we request SST Director's Discretionary Time for follow-up IR observations of the likely transient dust emission from this object. We request that IRS spectroscopy, together with IRAC+MIPS photometry, be obtained as early as possible (the supernova could fade to a level several times weaker than on June 10th 2004 and still produce good signal-to-noise ratios throughout most of the IRS spectral domain). As well as allowing the object's overall energy distribution to be constrained, the spectra will enable any dust emission or absorption features to be identified (an Av of 5.0 local to the SN has been deduced), together with any ionic emission lines. Accompanying short-duration IRAC 4-band and MIPS 24-um imaging will provide higher angular resolution than the IRS

Spitzer Space Telescope - General Observer Proposal #30652

Spitzer-IRS's view of Halo PNe

Principal Investigator: Jeronimo Bernard-Salas
Institution: Cornell University

Technical Contact: Jeronimo Bernard-Salas, Cornell University

Co-Investigators:
Stuart R Pottasch, Kapteyn Astronomical Institute
Els Peeters, SETI Institute
Patrick W. Morris, NASA Herschel Center, CalTech

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 5.3

Abstract:
We propose to observe a sample of 4 Halo planetary nebulae (PNe) using the IRS spectrograph on board Spitzer. The planetary nebula phase is ideal to obtain accurate abundances and the study of halo planetary nebulae offers a great opportunity to understand the chemical evolution of the Galactic halo which is still in debate. Halo PNe are very rare, out of 2000 known PNe in the Galaxy only 10 belong to the halo. They presumably have low progenitor masses and seem to show subsolar oxygen abundance, as well as low abundance of other heavier elements. However, several studies have clearly shown that the oxygen abundance can be strongly affected by nucleosynthesis, rendering the Ar/O and S/O ratios (often used in the literature) not useful. In addition, the study of the abundance of sulfur and argon (elements not suppose to change in the course of evolution of low- and intermediate-mass stars) is hampered by the fact that these elements emit most of their energy in the infrared. For these reasons, The abundances variations from source to source haven't been able to be confirmed. Ground based efforts have been made to measure lines of these elements in the infrared, but only in one halo PN this has been successful. The IRS spectrograph on board the Spitzer Space Telescope covers the ideal wavelength range where most of the lines from these elements are emitted, plus it has the superb sensitivity to study these objects. Because of this, Spitzer provides an ideal opportunity to obtain accurate abundances and give important insight in the halo composition. Moreover, the infrared data offer a good opportunity to study the dust, and the halo PNe provides a perfect laboratory to study the properties of the dust in a low metallicity environment in our own Galaxy.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40035

Measuring the Metallicity Gradient in the Outer Disk of the Milky Way

Principal Investigator: Jeronimo Bernard-Salas
Institution: Cornell University

Technical Contact: Jeronimo Bernard-Salas, Cornell University

Co-Investigators:
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Stuart, R. Pottasch, Kapteyn Astronomical Institute
Shannon Guiles, Cornell University
Patrick, W. Morris, NASA Herschel Science Center, IPAC/Caltech

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 18.0

Abstract:
It has been known for many years that there is an abundance gradient in the Galaxy. This has been verified by studies of HII regions, young stars and Cepheid variables. While the gradient is well characterised in the solar neighborhood its behavior is more uncertain in the bulge and in the anti-galactic center regions. For instance, results from HII regions indicate that the gradient in the outer part of the Galaxy decreases, but this is not supported from the works on early type stars, and Cepheid results suggest a flattened gradient in the solar vicinity. Planetary Nebulae (PNe) are ideal objects to solve these discrepancies because their abundances can be accurately determined. Certain elements, like sulfur, neon and argon are neither produced nor destroyed in the course of evolution of low- and intermediate-mass stars and therefore represent the composition at the time of star formation. These elements emit many lines in the infrared part of the electromagnetic spectrum and thus, infrared observations are essential to derive their abundances. Infrared observations of PNe have recently been used by Pottasch & Bernard-Salas (2006) to study the Galactic gradient in the solar vicinity using data from the Infrared Space Observatory (ISO). The gradient found reproduces exactly the solar metallicity at 8kpc. The enhanced sensitivity of Spitzer enables one to extend this study to the outer regions of the Galaxy. The study of bulge PNe using the IRS instrument on board Spitzer is the subject of an earlier proposal. With the present proposal we want to study a selection of 24 PNe in the outer part of the Galaxy to fully characterise the gradient in the Galaxy. In addition, we include in this proposal observations of four (extended) PNe. These four PNe have well known distances and will anchor these relations.

Spitzer Space Telescope - General Observer Proposal #3413

Kepler's SNR at 400 Years: A Dust Processing Laboratory

Principal Investigator: William Blair
Institution: Johns Hopkins University

Technical Contact: William Blair, Johns Hopkins University

Co-Investigators:
Ravi Sankrit, Johns Hopkins University
Parviz Ghavamian, Johns Hopkins University
Kazimierz Borkowski, North Carolina State University
Stephen Reynolds, North Carolina State University
Knox Long, Space Telescope Science Institute

Science Category: evolved stars/pn/sne
Observing Modes: IracMap MipsPhot MipsSed
Hours Approved: 5.6

Abstract:
We propose MIPS and IRAC imaging and MIPS SED spectroscopy of Kepler's supernova remnant to study the characteristics of dust and the spatial variations of that dust between various well-defined parts of the remnant. The key regions of the SNR include the NW region (dominated by shocked circumstellar and interstellar material), the bright X-ray/radio northern arc (where shocked ejecta and an apparent reverse shock are prevalent), the SE limb (dominated by synchrotron emission), and the central region (which could in principle hide unshocked cold ejecta). The combination of MIPS and IRAC imaging, especially when combined with multiwavelength data sets, will permit us to study hot and cold dust components and their spatial variation, and observe or place limits on IR sychrotron emission. A key question we will answer is whether IR dust signatures in Kepler's SNR arise in shocked ISM, ejecta, or both, and what the total mass of dust is. This latter point will help determine the precursor star and SN type for the Kepler supernova. If the dust emission is indeed dominated by swept-up ISM dust, we will be able to study dust grain destruction behind the primary shock front by comparing the MIPS and IRAC morphologiesi to dust models. MIPS SED R=20 spectra will assess the presence of any strong shock cooling lines such as [OI] 63 um and allow any impacts on the imaging data to be assessed.

Spitzer Space Telescope - General Observer Proposal #3167

The dust sequence along the AGB

Principal Investigator: Joris Blommaert
Institution: Instituut voor Sterrenkunde Leuven

Technical Contact: Joris Blommaert, Instituut voor Sterrenkunde Leuven

Co-Investigators:
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Alain Omont, Inst. d'Astrophysique Paris
Mathias Schultheis, Observatoire de Besancon
Xander Tielens, Kapteyn Institute
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Rens Waters, Astronomical Institute 'Anton Pannekoek'
Peter Wood, Mt.Stromlo

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 14.4

Abstract:
The evolution of stars on the Asymptotic Giant Branch (AGB) is characterized by substantial mass loss, producing large amounts of circumstellar dust and a dust-driven outflow, which injects the stellar ejecta into the interstellar medium. Here we propose to spectroscopically observe a homogeneous sample of AGB stars in the Galactic bulge with Spitzer-IRS from 5.2 to 38 micron with the aim to study the variations in dust composition for 1 solar mass stars as they evolve along the AGB. The Spitzer-IRS wavelength range 5.2 - 38 micron contains the major spectral features of aluminum oxides, spinel, magnesium-iron oxides as well as those of amorphous and various crystalline silicates. Previous studies have shown these components to be abundant in AGB environments, albeit with highly varying relative abundances. The stars in our sample all originate from 1 solar mass stars, and only differ in their ages along the AGB. Moreover, this sample fully covers the range in AGB mass-loss rates, from the onset of mass loss on the AGB up to the superwind phase. The proposed observations with Spitzer-IRS will be coordinated with ground-based observations to obtain simultaneous information on other stellar parameters (such as pulsational phase). With the proposed observations we can therefore link for the first time the spectral differences in dust composition directly to the age on the AGB. Such observations therefore offer the opportunity to comprehensively study the composition and evolution of the circumstellar dust of a 1 solar mass star as it climbs the AGB. The proposed observations will provide a unique observational baseline for studies of dust evolution in AGB stars in our own and other galaxies.

Spitzer Space Telescope - General Observer Proposal #3633

Galactic Bulge Planetary Nebulae as Probes of Stellar Evolution

Principal Investigator: Matthew Bobrowsky
Institution: CSC/STScI

Technical Contact: Matthew Bobrowsky, CSC/STScI

Co-Investigators:
Pedro García-Lario, ISO Data Centre, ESA
José Perea Calderón, ISO Data Centre, ESA

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 10.0

Abstract:
The study of the physical properties of planetary nebulae (PNe) is hampered in our Galaxy by the poor knowledge of their distances. This problem can be overcome if we concentrate our analysis on well- defined samples where the distance is known with a reasonable accuracy, as is the case of the Galactic Bulge population of PNe. We propose to obtain 5-37 um IRS spectra of a carefully selected sample of bulge PNe, where these sources are characterized by the presence of a combination of solid state features (from the dust grains) and nebular emission lines superimposed on a strong dust continuum. With the Spitzer Space Telescope we will be able to: (i) determine the dominant chemistry (C-rich vs. O-rich) of the PN dust through the study of the solid state features; (ii) establish connections between the spectral properties observed in the infrared spectra and the evolutionary stage of the PNe; (iii) test the current evolutionary models which predict the dredge-up of processed material to the surface as a function of the mass of the progenitor star; (iv) recover the AGB mass loss history from the analysis of the overall spectral energy distribution with the help of time-dependent hydrodynamical models; (v) determine the contribution of the infrared to the total PN luminosity; (vi) study the influence of the metallicity on the initial mass - final mass relation deduced from the observations; and (vii) derive the physical parameters and chemical abundances of the ionized gas with unprecedented accuracy by measuring the nebular emission lines detected in the infrared after this information is combined with ground-based spectroscopy in the optical and/or in the UV.

Spitzer Space Telescope - General Observer Proposal #30432

Are metal-rich hot white dwarfs accreting from dust disks or substellar companions?

Principal Investigator: Matt Burleigh
Institution: University of Leicester

Technical Contact: Matt Burleigh, University of Leicester

Co-Investigators:
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Paul Dobbie, University of Leicester (UK)
Ralf Napiwotzki, University of Hertfordshire (UK)
Carolyn Brinkworth, Spitzer Science Center / JPL
Donald Hoard, Spitzer Science Center
Stefanie Wachter, Spitzer Science Center
Hans Zinnecker, Astrophysikalisches Institut Potsdam (Germany)
Susanne Freidrich, MPE (Germany)
Serge Correia, Astrophysikalisches Institut Potsdam (Germany)

Science Category: evolved stars/pn/sne
Observing Modes: IracMap
Hours Approved: 13.9

Abstract:
Previous mid-IR observations of white dwarf stars have revealed that a small number possess debris dust disks and brown dwarf companions, marked by a mid-IR photometric excess over the expected flux from the white dwarf photosphere. The debris dust disks may originate from the tidal disruption of an asteroid or comet, indicating the presence of an old solar system. These disks have specifically been seen in a subset of cool white dwarfs with metal-rich atmospheres (the DAZs) and with temperatures between 10,000K and 15,000K. The white dwarfs are thought to accrete from this dusty material. We propose to survey with Spitzer a sample of much hotter white dwarfs (T>30,000K) which also have peculiar, unexplained metal abundances (determined by us from previous soft x-ray, EUV and far-UV observations). Through searching for excess mid-IR emission with IRAC, we aim to determine whether these white dwarfs also possess debris dust disks, from which they are accreting. Alternatively, these mid-IR observations may reveal the presence of close, substellar companions that are influencing the white dwarfs' atmospheric composition via wind accretion.

Spitzer Space Telescope - General Observer Proposal #20654

EP Aqr: the Rosetta rocks of astro-archeology

Principal Investigator: Jan Cami
Institution: NASA Ames Research Center

Technical Contact: Jan Cami, University of Western Ontario

Co-Investigators:
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Els Peeters, NASA Ames Research Center

Science Category: evolved stars/pn/sne
Observing Modes: IrsMap IrsStare
Hours Approved: 2.1

Abstract:
The evolution of stars on the Asymptotic Giant Branch (AGB) is characterized by substantial mass loss, producing large amounts of circumstellar dust and a dust-driven outflow, which injects the stellar ejecta into the interstellar medium. The composition of this newly formed dust is known to vary substantially from source to source, which is generally thought to reflect differences in the mass loss rate (e.g., density). During the evolution of the star on the AGB, the mass loss rate is known to vary substantially leading to large density variations and detached shell structures. Observations of bright examples of such shells provide us thus with the opportunity to dig into the past history of the mass loss processes from these objects. We propose to spectroscopically map the extended but bright outflow of the nearby AGB star, EP Aqr, with Spitzer-IRS from 5.2 -- 38 micron. In this way we will be able to trace the composition and mass of the dust formed at different times (e.g., corresponding to thousands of years of mass loss history). The IR spectrum of EP Aqr contains the spectral fingerprints of nearly all minerals (alumina, spinel, magnesium-iron oxides, amorphous and possibly crystalline silicates, gehlenite, ...) found in the dust shells surrounding O-rich AGB stars, which makes it an ideal target for such a dust astro-archeology study. The proposed observations will therefore directly link for the first time the spectral differences in dust composition to the mass loss history of the central star. Such observations will also provide important clues to large-scale structure of AGB star outflows as well as to theoretical models for dust formation and mass-loss mechanisms.

Spitzer Space Telescope - General Observer Proposal #40848

Crystalline silicates in Bulge AGB stars

Principal Investigator: Jan Cami
Institution: SETI Institute

Technical Contact: Jan Cami, SETI Institute

Co-Investigators:
Joris Blommaert, Insititute for Astronomy, KU Leuven
Alexander Tielens, NASA Ames Research Center
Kay Justtanont, Stockholm Observatory
Evelien Vanhollebeke, Institute for Astronomy, KU Leuven
Ciska Kemper, University of Manchester

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 16.5

Abstract:
Mid-IR spectroscopic observations of O-rich AGB stars generally show the presence of copious amounts of circumstellar dust, often characterized by strong emission or absorption due to amorphous silicates. Detectable fractions of crystalline silicates have so far only be found in stars with high mass loss rates. Here we propose to spectroscopically observe -- using Spitzer-IRS from 9.9 -- 37.2 micron at high-resolution -- a homogeneous sample of 13 O-rich AGB stars spanning a large range in mass loss rates, and which all show tantalizing evidence for the presence of crystalline silicates in their low resolution spectra. The target stars are selected from a sample of O-rich AGB stars in the Galactic Bulge that was observed with IRS at low resolution with the aim to study the variations in the dust composition as a 1.5 solar mass star evolves along the AGB. The proposed observations will allow us to i) unambiguously confirm the presence of crystalline silicates in AGB stars with low- to intermediate mass loss rates; ii) determine at what phase in the AGB crystalline silicates are first formed and hence where they fit in the dust condensation sequence for O-rich AGB stars iii) determine the temperature and chemical composition of these crystalline silicates and hence iv) understand how these crystalline silicates are formed and how they evolve as they sail away from the central star; and finally v) what stellar parameters are important for the efficient formation of crystalline silicates.

Spitzer Space Telescope - General Observer Proposal #40896

The dust disk of HR 4049

Principal Investigator: Jan Cami
Institution: SETI Institute

Technical Contact: Jan Cami, SETI Institute

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 0.4

Abstract:
HR 4049 is the prototype of a class of binary post-AGB stars with very peculiar properties. One of those surprising properties is the presence in the IR spectrum of gas species typically found in O-rich environments (carbon dioxide, water, OH) at the same time as species typical for C-rich environments (HCN, Polycyclic Aromatic Hydrocarbons, nanodiamonds). Moreover, the carbon dioxide bands require an extreme enrichment in 17O and 18O isotopes of nearly 3 orders of magnitude. Previous IR observations have indicated the presence of a massive and vertically extended disk surrounding the entire binary system. This disk is important to explain the peculiar abundance pattern in the stellar photosphere, but may be equally important for understanding the simultaneous occurence of O-rich and C-rich species in this object. Crucial in this context is the nature (O-rich vs C-rich) of the dust disk at the inner rim. Currently available IR observations do not allow to establish the nature of the dust. Here, we propose to observe HR 4049 with Spitzer-IRS using the LH module in order to study the composition of the dust in the circumbinary disk by searching for dust features at wavelengths between 19.3 and 36 micron.

Spitzer Space Telescope - General Observer Proposal #50808

IRS investigation of 24 micron compact ring sources

Principal Investigator: Sean Carey
Institution: Spitzer Science Center

Technical Contact: Sean Carey, SSC

Co-Investigators:
Alberto Noriega-Crespo, Spitzer Science Center
Sachin Shenoy, Spitzer Science Center
Roberta Paladini, Spitzer Science Center
Schuyler VanDyk, Spitzer Science Center
Patrick Morris, NHSC/IPAC

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 3.7

Abstract:
We propose IRS observations of seven compact ring and bubble like sources identified in the MIPSGAL Legacy survey images. These sources were previously unknown and are representative of > 100 compact sources in the MIPSGAL survey data. The spectra will be used to determine whether these objects are lower mass evolved stars, massive evolved stars or supernova remnants similar to the one found by Morris et al. (2006). This inquiry is highly speculative as we have little information regarding these objects, but Spitzer is the only observatory that can further ascertain their physical properties.

Spitzer Space Telescope - General Observer Proposal #3718

Search for Fallback Disks in Young Supernova Remnants

Principal Investigator: Deepto Chakrabarty
Institution: Massachusetts Institute of Technology

Technical Contact: Deepto Chakrabarty, MIT

Co-Investigators:
Zhongxiang Wang, Massachusetts Institute of Technology

Science Category: evolved stars/pn/sne
Observing Modes: IracMap
Hours Approved: 9.3

Abstract:
Fallback disks are a general prediction of core-collapse supernova models, yet there are few observational constraints on the size (or existence) of these disks. If they exist, these disks could significantly affect the evolution of pulsars and could even lead some neutron stars to collapse into black holes. Theory predicts that fallback disks around young neutron stars should be strong IR emitters due to irradiation from the central X-ray source. The radio-quiet, compact X-ray point sources detected near the centers of several core-collapse supernova remnants offer a superb opportunity to make a very sensitive search for the predicted emission from fallback disks. The anomalous X-ray pulsars may also be another promising set of targets. We propose to obtain deep IR images of 5 radio-quiet neutron stars and one anomalous X-ray pulsar, and to combine these with existing ground-based optical and near-IR data to test the existence of fallback disks.

Spitzer Space Telescope - Directors Discretionary Time Proposal #225

Spitzer Observations of a WZ Sge-Type Dwarf Novae in Superoutburst

Principal Investigator: David Ciardi
Institution: Michelson Science Center

Technical Contact: David Ciardi, Michelson Science Center

Science Category: evolved stars/pn/sne
Observing Modes: IracMap MipsPhot
Hours Approved: 5.0

Abstract:
On 2004 June 16, a previously unknown star in Hercules went into outburst (IAUC #8363). Preliminary optical spectra from 0.37 - 0.75um and 0.7 - 0.9 um, taken after the outburst was reported, indicate that the outbursting star is a cataclysmic variable of the WZ Sge dwarf novae type. As WZ Sge-type dwarf novae rarely outburst (timescales of decades), we are proposing to take advantage of this unique opportunity and observe the outburst with Spitzer - a chance that may never come again. The requested IRAC and MIPS observations will be used to explore the question of whether dust is formed in the ejecta of the outburst, and thus, explain an observed dip in the optical light curves of WZ Sge-type dwarf novae which has remained unexplained for nearly six decades.

Spitzer Space Telescope - General Observer Proposal #30029

The Shells of R Coronae Borealis Stars: Fossil Planetary Nebulae?

Principal Investigator: Geoffrey Clayton
Institution: Lousiana State University

Technical Contact: Geoffrey Clayton, Lousiana State University

Co-Investigators:
Karl Gordon, Steward Observatory
Orsola De Marco, American Museum of Natural History
Warrick Lawson, Australian Defence Force Academy
Howard Bond, STScI
Ben Sugerman, STScI

Science Category: evolved stars/pn/sne
Observing Modes: MipsScan
Hours Approved: 7.2

Abstract:
IRAS observations detected extended arcminute-size shells around five R Coronae Borealis (RCB) stars but due to its poor spatial resolution no detailed maps of these shells exist. R CrB, itself, has an 18′ shell at 100 microns. Twenty years later, this shell is still unexplained. But the shell around R CrB and other RCB stars hold clues to the evolutionary history of these stars. The RCB stars are rare hydrogen-deficient and carbon-rich supergiants. Their rarity may stem either from them being in an extremely rapid phase of evolution, or from them being in an evolutionary phase that most stars are able to avoid. Two contending evolutionary scenarios have been suggested to account for RCB stars: they arise from a merger of two white dwarfs, or from a single star which has evolved to become a planetary-nebula central star and only then undergoes a final helium shell flash which returns it to a cool supergiant configuration. The proposed MIPS maps will provide images of the RCB IRAS shells, which are fossil records of previous evolutionary stages of these stars. For instance, an old Planetary Nebula shell would no longer be ionized and is now seen in IR emission from dust. Understanding the RCB stars is a key test of for any theory which aims to explain the evolution of post AGB stars and hydrogen deficiency.

Spitzer Space Telescope - General Observer Proposal #30380

Looking for Dual Dust Chemistry in the Shells of Hot R Coronae Borealis Stars

Principal Investigator: Geoffrey Clayton
Institution: Lousiana State University

Technical Contact: Geoffrey Clayton, Lousiana State University

Co-Investigators:
Karl Gordon, Steward Observatory
Orsola De Marco, American Museum of Natural History
Warrick Lawson, Australian Defence Force Academy
Howard Bond, STScI
Don Pollacco, Queen's University Belfast
Michael Barlow, University College London

Science Category: evolved stars/pn/sne
Observing Modes: IrsPeakupImage IrsStare
Hours Approved: 1.0

Abstract:
Detecting the presence of dual dust chemistry will establish a definitive link between RCB stars and the [WC] central stars of PNe. More importantly, given the established relationship between dual dust chemistry and binarity, this program could be the first to firmly determine a link between the RCB phenomenon and binarity, constituting a large step towards resolving the origin of RCB stars and the phenomenon of H-deficiency on the AGB. The RCB stars are rare hydrogen-deficient carbon-rich supergiants, consistent with being post-AGB stars. Evolutionary scenarios have been suggested including, a merger of two stars, or a final helium shell flash. While most RCB stars are relatively cool (<7000 K), a few are significantly hotter (~20,000 K). Two of these stars, V348 Sgr and HV 2671 show similarities to the [WC] central stars of PNe such as CPD -56 8032, which shows RCB-like dust formation. CPD -56 8032 shows emission features of PAHs as well as crystalline silicates, indicating a dual dust chemistry, i.e., the simultaneous presence of both C-rich and O-rich dust. These systems may all be binaries in which the O-rich silicates are trapped in a disk as a result of a past mass transfer event, with the C-rich particles being more widely distributed in the nebula as a result of recent ejections of C-rich material. We will use the IRS to obtain spectra in the Short-Low and Long-Low modes to look for evidence of a similar dual dust chemistry in the shells of the two hot RCB stars, V348 Sgr and the LMC star, HV 2671. In the large nebula around V348 Sgr, we may be able to see a spatial separation between the O-rich dust in a disk close to the star and the C-rich dust spread through the nebula, which would strongly support the binary/disk model for dual dust chemistry. For a very small expenditure of Spitzer Space Telescope time, we may be able to provide for the first time a real connection between the RCB and [WC] central stars.

Spitzer Space Telescope - Archive Research Proposal #40210

LMC Planetary Nebulae: IR Luminosity Functions, AGB Halos, and a Spitzer Search for New Candidates

Principal Investigator: Martin Cohen
Institution: University of California, Berkeley

Technical Contact: Martin Cohen, University of California, Berkeley

Co-Investigators:
Joseph Hora, Harvard-Smithsonian, CfA, USA
Quentin Parker, Macquarie University, Australia
Warren Reid, Macquarie University, Australia

Science Category: evolved stars/pn/sne
Dollars Approved: 100456.0

Abstract:
One of the longest standing and most difficult astronomical problems is to determine the relation between the birth mass of stars and the mass left when they die. Most mass lost by 1-8 solar mass stars occurs during rapid evolution on the asymptotic giant branch (AGB). Towards the end of its life, a star sheds its outer layers as a planetary nebula (PN) but little matter is expelled. The hot, remnant star ionizes the PN and previous ejecta. PN ionized gas is ~0.1 solar masses so most of a progenitor star's mass must be dispersed into a large faint envelope: an AGB halo. Techniques exist to measure stellar core mass, ionized nebula and faint halo once a PN is identified and its halo recognized, but only if we know the PN's distance. The Large Magellanic Cloud (LMC) distance is well established while its geometry implies all its PNe share this distance. We propose a combined IR, optical and radio study of all known LMC PNe observed by the SAGE Legacy project. The enhanced products, due for release in 2007-8, will provide photometry of unresolved PNe. Fluxes of resolved PNe will be extracted from IRAC/ MIPS images. Of 693 LMC PNe observed by SAGE, 233 were found optically prior to SAGE and 460 newly found by Co-Is Reid and Parker in an ultra-deep H-alpha survey of the LMC's central 25sq.deg. Their survey is a unique database of optical spectra and H-alpha images in which 280 new, faint, AGB halos have also been discovered. Our goals are to: seek IR matches to AGB halos and estimate total dust masses of their PNe; combine these with Gemini/VLT optical spectra of ~30 PN central stars, their shells and halos to provide an unrivaled sample of PNe for which we will derive masses of total ejecta and stellar core to define an independent initial-final mass relation. We will also enlarge the LMC census by seeking PNe in SAGE source lists by their IR colors and create new IR and radio luminosity functions for LMC PNe to compare with our unprecedentedly complete new [OIII] and H-alpha luminosity functions.

Spitzer Space Telescope - General Observer Proposal #50717

An Interferometric Snapshot Survey to Constrain Mass-Loss Dynamics and Physics in AGB Stars

Principal Investigator: Michelle Creech-Eakman
Institution: New Mexico Institute of Mining and Technology

Technical Contact: Michelle Creech-Eakman, New Mexico Tech

Co-Investigators:
Joseph Hora, Harvard-Smithsonian - CfA
Zeljko Ivezic, Univ of Washington
Colby Jurgenson, Magdalena Ridge Observatory -- NMT
Don Luttermoser, East Tennessee State Univ.
Massimo Marengo, Harvard-Smithsonian CfA
Robert Stencel, Univ of Denver
Robert Thompson, CHARA Array -- GSU

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 25.6

Abstract:
We propose Spitzer IRS observations of a unique sample of 25 AGB (mira) variable stars with interferometrically determined K-band angular diameters and spectrophotometry taken simultaneously using the Palomar Testbed Interferometer. These high-resolution spectral and spatial observations, in conjunction with amateur light-curves (e.g. AAVSO), will be used together to place constraints on the location of the IR stellar photosphere and the nature of the molecules and dust in the circumstellar environment (CSE). We can then develop complete models of the stars and CSE, using our state-of-the-art hydrodynamic atmosphere codes (ATLAS/PANDORA) and radiative transfer code (DUSTY). This will allow us to undertake the most accurate modeling of these highly dynamic environments that has yet been done for evolved stars. With results from these observations we will answer several key questions about these stars including: 1) how important are the roles of NLTE atmospheres in the formation of dust?; 2) what dust species are relevant to a given AGB dust morphology and do these change as a result of the pulsational cycle?; 3) is dust created or destroyed during the pulsational cycle and how does this relate to the abundances of other molecules in the CSE?; and finally, 4) what is the physical location of the dust production around an AGB star which acts to define the age-dependent spectral-energy distribution? These types of observations require a high-level of spectroscopic fidelity, repeatability and sensitivity which is unable to be executed under conditions of telluric contamination. Therefore these types of observations can only be performed with Spitzer's IRS instrument.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #93

Survey of PAH Emission, 10-19.5 um

Principal Investigator: Dale Cruikshank
Institution: NASA-Ames

Technical Contact: Kris Sellgren, Ohio State University

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 15.2

Abstract:
A survey of the emission bands in the region 10-19.5 um, in planetary nebulae, proto-planetary objects, YSOs/HII regions, and related sources. The study will focus on the emission band at 16.4 um, attributed to PAHs, and will include the plateau of emission that extends from 15 um to the long wavelength limit of the Short-High IRS module.

Spitzer Space Telescope - General Observer Proposal #40224

The pre-supernova mass-loss behaviour of Red Supergiants

Principal Investigator: Ben Davies
Institution: Rochester Institute of Technology

Technical Contact: Ben Davies, Rochester Institute of Technology

Co-Investigators:
Don Figer, RIT
Jacco van Loon, Keele University, UK
Joel Kastner, RIT

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 17.1

Abstract:
The mass lost by massive stars as they pass through the Red Supergiant (RSG) phase is a crucial determinant in the terminal mass of the star, the nature of the resulting supernova explosion and the stellar end-state. However, up until now studies of this quantity have been problematic, owing to the low numbers of known RSGs and the difficulty of observing in the mid-IR. Here, we capitalize on the recent discoveries of two remarkable Galactic clusters containing unprecedented numbers of RSGs, and use the capabilities of {it Spitzer} to undertake a comprehensive and unique study of the pre-SN mass-loss of massive stars. We will use {it Spitzer/IRS} observations in conjunction with state-of-the-art dust models to provide the first quantitative investigation of the mass and composition of the pre-SN ejecta as a function of age and metallicity. This study is vital in determining the mass-loss behaviour of RSGs in particular, and the nature of supernova progenitors in general.

Spitzer Space Telescope - General Observer Proposal #50168

Dusty Disks Around PG1159 Stars

Principal Investigator: Orsola De Marco
Institution: American Museum of Natural History

Technical Contact: Orsola De Marco, American Museum of Natural History

Co-Investigators:
Geoffrey Clayton, Louisiana State University
Jason Nordhaus, University of Rochester
Thomas Rauch, Eberhard Karls University
Klaus Werner, Eberhard Karls University
You-Hua Chu, University of Ilinois

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare IrsPeakupImage
Hours Approved: 6.0

Abstract:
The recent detection of old dusty white dwarfs (WDs) has been interpreted as signaling the presence of debris disks around these objects. Alternatively, this WD dust could be a remnant from the asymptotic giant branch phase. In any case, this old circumstellar dust is of great interest because it has survived for long periods around very hot stars. The dusty environments of the hydrogen-deficient central stars of planetary nebula (PN) have, since the days of ISO, raised similar questions about dust lifetimes, processing, and how different types of dust can be used as markers for different evolutionary channels. The PG1159 central stars are the last phase of the evolution of the hydrogen-deficient central stars of PN, just before the PN disperses and the star becomes a non-DA WD. Half of these stars are bright IRAS sources indicating that, like their progenitors, they are dusty. We seek to obtain IRS spectra of these IRAS-detected PG1159 stars, to determine dust composition and spatial distribution, which can help to answer: (i) how dust evolves with age and how it can survive so that it is still present around older WDs, and (ii) how dust evolution can be coupled to stellar evolution to aid in the determination of evolutionary channels.

Spitzer Space Telescope - Directors Discretionary Time Proposal #264

Insight into the Progenitor of the Type Ia Supernova 2005gj

Principal Investigator: Darren DePoy
Institution: Ohio State University

Technical Contact: Jose Prieto, Ohio State University

Co-Investigators:
Jose Prieto, Ohio State U.
Peter Garnavich, U. Notre Dame
Gaston Folatelli, Carnegie Institution of Washington
Mario Hamuy, Universidad de Chile
Masao Sako, SLAC, Standford U.
Joshua Frieman, Fermilab, U. Chicago

Science Category: evolved stars/pn/sne
Observing Modes: IracMap
Hours Approved: 0.8

Abstract:
We propose to measure the spectral energy distribution of the unusual and exciting supernova 2005gj. This event is only the second clear case of a thermonuclear explosion going off in a dense circumstellar environment (SN 2002ic was the first) and is a rare opportunity to characterize properties of the companion star thought to be donating mass to the white dwarf primary. SN 2005gj was discovered by the Sloan Digital Sky Survey Supernova Search and has a more extensive optical/near-IR light curve and spectral coverage than the previous event. Here we request IRAC observations to extend the SED into far-IR to search for early evidence of dust emission. The next visibility window opens before Cycle-3 begins so we are requesting Director Discretionary Time for this object.

Spitzer Space Telescope - General Observer Proposal #30733

Insight into the Progenitor of the Type Ia Supernova 2005gj

Principal Investigator: Darren DePoy
Institution: Ohio State University

Technical Contact: Jose Prieto, Ohio State University

Co-Investigators:
Jose Prieto, The Ohio State University
Peter Garnavich, University of Notre Dame
Gaston Folatelli, Carnegie Institution of Washington/Las Campanas Ob
Mario Hamuy, Universidad de Chile
Masao Sako, KIPAC/Stanford University
Carlos Contreras, Carnegie Institution of Washington/Las Campanas Ob

Science Category: evolved stars/pn/sne
Observing Modes: IracMap MipsPhot
Hours Approved: 4.3

Abstract:
We propose to measure the evolution of the spectral energy distribution of the unusual and exciting supernova 2005gj. This event is only the second clear case of a thermonuclear explosion going off in a dense circumstellar environment (SN 2002ic was the first) and is a rare opportunity to characterize properties of the companion star thought to be donating mass to the white dwarf primary. SN 2005gj was discovered by the Sloan Digital Sky Survey Supernova Search and has a more extensive optical/near-IR light curve and spectral coverage than the previous event. A first epoch of IRAC imaging to study early dust emission was obtained through a DDT proposal. Here we request IRAC and MIPS observations to extend the SED into far-IR to study the late time emission from dust.

Spitzer Space Telescope - General Observer Proposal #30430

Do s-Process Enhanced Planetary Nebulae Have Unusual Dust Emission Spectra?

Principal Investigator: Harriet Dinerstein
Institution: The University of Texas at Austin

Technical Contact: Harriet Dinerstein, The University of Texas at Austin

Co-Investigators:
Nicholas Sterling, The University of Texas at Austin
Kris Sellgren, Ohio State University

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 7.5

Abstract:
We propose to obtain IRS observations of the mid-infrared dust emission of a sample of Galactic planetary nebulae (PNs) which are known to have enrichments of elements produced in the precursor star by slow neutron-capture nucleosynthesis (the "s-process"). These enhanced abundances result from captures of free neutrons by Fe-peak nuclei following by convective mixing during the AGB; this "third dredge-up" is also responsible for increasing the surface abundance of carbon. Since PNs are the descendants of AGB stars and are often C-rich, it is not surprising that we find substantial enrichments of s-process products such as Ge, Se, and Kr in some PNs. Despite their low initial abundances, 1e-9 to 1e-10 times H, modest enrichments of neutron-capture elements can have observable effects. The spectral type S, a transitional class between O-rich and C-rich AGB stars, is characterized by prominent ZrO bands; Zr is produced in the s-process. We have attempted, without success, to detect gas-phase Zr in PNs. However, Zr is highly refractory. It can condense into ZrO2 or be incorporated into high-temperature rocky condensates in O-rich environments, while in C-rich environments it may form metallic carbides (i.e. ZrC, an analog of TiC). Indeed, Zr-Mo carbide inclusions found in some meteoritic presolar grains are thought to originate in the atmospheres of C-rich AGB stars. Other refractory s-process products (e.g. Sr, Ba) may also be incorporated into grains. High-quality Spitzer spectra of the dust emission in a set of PNs with known s-process enhancements - determined by us from gas-phase measurements of undepleted elements - will be valuable for comparison with laboratory spectroscopy of grain analogs. These comparisons will help determine whether the dredge-up of n-capture products affects the dust chemistry of PNs and may offer some new insights into the dust composition.

Spitzer Space Telescope - General Observer Proposal #40536

A Search for Cold, Metal-Rich Gas in Planetary Nebulae: Testing the Chemically Inhomogeneous Model

Principal Investigator: Harriet Dinerstein
Institution: University of Texas, Austin

Technical Contact: Harriet Dinerstein, University of Texas at Austin

Co-Investigators:
Kris Sellgren, Ohio State University

Science Category: evolved stars/pn/sne
Observing Modes: IrsMap
Hours Approved: 14.8

Abstract:
We propose to obtain IRS spectral maps of 3 spatially extended planetary nebulae (PNe) in order to test the currently popular proposal that there are inclusions of cold, hydrogen-deficient material within the normal, hot, ionized gas. The presence of such cold (T < 1000 K) inclusions was suggested in order to account for the anomalous strength of the optical recombination lines (ORLs) of heavy elements such as O, C, N, and Ne in a number of PNe, as well as the discrepant electron temperature values that are found when different diagnostics are applied to a given nebula. If such cold, metal-rich (by factors of 10 - 100) material is really present, this represents a major change in our picture of PNe (and also many H II regions which exhibit similar behavior), which we can no longer think of as possessing a single chemical composition. Since infrared emission lines from low energy states are emitted by the cold material nearly as efficiently as from warmer gas, infrared spectroscopy is the ideal way to test this picture, independently of the recombination line observations themselves. We will use the SH setup on the IRS, which enables us to simultaneously map emission lines from 3 ions of Ne: [Ne II], [Ne III], and [Ne V], thereby circumventing the potential problem of ionization balance variations with position. We have chosen targets which are already known to display large anomalies in the optical recombination lines of neon (specifically, Ne II, which traces triply-ionized Ne) as well as in O, C, and N, and will obtain new, complementary ground-based spectral maps of the ORLs for direct comparison with the Spitzer maps. Whether or not we are able to spatially localize the cold, line-emitting material, we expect the Spitzer data to provide novel and fundamental constraints and insights on the physical state and chemical constituents of the nebular gas.

Spitzer Space Telescope - General Observer Proposal #20713

Probing the Mysterious IR excess in Close Binary Stars

Principal Investigator: Jeremy Drake
Institution: Harvard-Smithsonian Center for Astrophysics

Technical Contact: Jeremy Drake, Harvard-CfA

Co-Investigators:
Massimo Marengo, Harvard-Smithsonian Center for Astrophysics
Vinay Kashyap, Harvard-Smithsonian Center for Astrophysics

Science Category: evolved stars/pn/sne
Observing Modes: IracMap MipsPhot
Hours Approved: 7.5

Abstract:
The RS CVn class of close binaries have an IR excess occurrence rate of 40% - more than twice as high as that for main-sequence stars or first ascent giants. These excesses are a mystery: the stars are generally older than the 400 Myr lifetime of dusty disks around MS stars, and stellar evolution does not predict substantial mass loss at their evolutionary phase. Spitzer IRAC and MIPS imaging and photometry of 10 nearby systems can distinguish between the competing models: long-lived dusty disks; new mass loss episodes at the subgiant or Hertzsprung gap phase; or magnetically-driven stellar winds and coronal mass ejections 100 times more massive than currently thought. The answers are important for understanding dusty disks, stellar magnetic activity, and for the evolution of close binary systems.

Spitzer Space Telescope - General Observer Proposal #50652

Follow-up observations of GLIMPSE selected Post-AGB candidates

Principal Investigator: Dieter Engels
Institution: Hamburger Sternwarte, U. Hamburg

Technical Contact: Dieter Engels, Hamburger Sternwarte, U. Hamburg

Co-Investigators:
Anibal Garcia-Hernandez, Instituto de Astrofisica de Canarias (IAC)
Pedro Garcia-Lario, European Space Astronomy Center

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 12.0

Abstract:
We propose to use the last Spitzer observing cycle to increase the sample of hidden post-AGB stars with mid-infrared spectroscopy. We selected predominantly GLIMPSE selected obscured objects tentatively identified as stars which have just abandoned the Asymptotic Giant Branch (AGB) and are now evolving to the planetary nebula (PN) stage. They are expected to represent the higher mass fraction of former oxygen-rich AGB stars and are suspected to be precursors of type I PNe. A high fraction of them shows a near infrared excess discovered in the GLIMPSE bands, indicating that as a consequence of strongly decreasing mass loss rates the surrounding circumstellar dust shell is becoming transparent again. Our sample is relatively faint at IRAS wavelengths so that they do not appear in IRAS color-selected samples. Based on our experience with Spitzer observations of an IRAS color selected sample, we will be able 1) to determine/confirm the chemical composition of the dust as O-rich, and possibly identify new mixed chemistry sources 2) to determine the dust grain structure (amorphous vs. crystalline) 3) to identify the solid state features superimposed on the dust continuum, in particular the relative amount of Al, Mg, Fe in the dust crystalline silicates 4) to study the correlation of the above observational properties with the evolutionary stage of the source, and 5) to identify new young infrared PNe, which may be associated to the high mass population of PNe The proposed Spitzer observing program is part of our efforts to understand the transition from AGB to PN while the stars are still in the earliest stages of the post-AGB phase. We found an astonishingly wide diversity of dust properties in their shells, probably because we observe them at different stages of their fast evolution. Due to their faintness at wavelengths shorter than 3 micron, Spitzer observations will be the last chance to study dust shells of hidden post-AGB stars for a long time.

Spitzer Space Telescope - General Observer Proposal #20262

Spitzer observations of old novae

Principal Investigator: Aneurin Evans
Institution: Keele University

Technical Contact: Aneurin Evans, Keele University

Co-Investigators:
Robert Gehrz, University of Minnesota
Charles Woodward, University of Minnesota
Elisha Polomski, University of Minnesota
Andrew Helton, University of Minnesota
Sumner Starrfield, Arizona State University
Joachim Krautter, Landessternewarte
Mark Wagner, University of Arizona
James Lyke, Keck Observatory
James Truran, University of Chicago
Alberto Salama, ESA

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 4.9

Abstract:
Our perception of old classical novae is determined by (i) the physical state of the stellar remnant as it heats up during the eruption, (ii) the distribution of the material ejected in the eruption, (iii) the eventual 'switching off' of the eruption. We propose to use Spitzer to obtain IRS stare spectra of several old novae (including 4 novae observed as targets-of-opportunity in Cy1) and MIPS photometry of old dusty novae, and of a unique nova with cold (possibly pre-eruption) dust. Our targets cover a range of nova parameter space (1-100 years since eruption, 'fast' and 'slow' novae, 'coronal' novae and dusty novae). Our objectives are to determine (i) element abundances in, and masses of, ejected material in the most recent eruptions, (ii) the physical state (density, temperature, clumpiness) of the ejected material, (iii) the long-term evolution of the dust in dusty novae, (iv) the physical state of the stellar remnant. Our goals are to investigate the long-term (10-100 years) evolution of classical novae and their environments, to gain an infrared perspective on the eruption 'turn-off' time, and to investigate the contribution that novae make to the chemical evolution of the Galaxy.

Spitzer Space Telescope - Directors Discretionary Time Proposal #270

Spitzer observations of the 2006 eruption of RS Ophiuchi

Principal Investigator: Aneurin Evans
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Technical Contact: Charles Woodward, Univ. Minnesota

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Richard Davis, Manchester
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Greg Schwarz, Arizona
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Joachim Osborne, Leicester
Kim Page, Leicester

Science Category: Evolved Stars/PN/SNE
Observing Modes: IrsStare
Hours Approved: 4.9

Abstract:
The recurrent nova RS Ophiuchi erupted on 2006 February 12, its first eruption since 1985. Unlike the case for 'classical' novae, in which the ejected material flows freely away from the site of the explosion, in RS Ophiuchi the ejected material is ploughing its way through a red giant wind. We are monitoring the 2006 eruption with Swift, Chandra, RXTE, XMM, VLA, and VLBA, giving us unprecedented insight into the physics of this interaction, and of the eruption itself. Spitzer is an essential part of this jigsaw, and will reveal the far-IR coronal and fine-structure line emission, the continuum from the hot shocked gas, and the effect of the eruption on the red giant.

Spitzer Space Telescope - General Observer Proposal #30076

Spitzer observations of adolescent novae

Principal Investigator: Aneurin Evans
Institution: Keele University

Technical Contact: Aneurin Evans, Keele University

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R. Mark Wagner, University of Arizona
Sumner Starrfield, Arizona State University
Andrew Helton, University of Minnesota
James Lyke, Keck Observatory
James Truran, University of Chicago
Steven Shore, Universita di Pisa
Mark Rushton, Keele University
Alberto Salama, European Space Agency

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 14.3

Abstract:
Classical novae (CNe) offer the best opportunity to observe many astrophysical processes (such as dust formation and processing, shaping of nebulae, gas cooling by IR fine structure lines) in ‘fast forward’. The CN eruption arises following a thermonuclear runaway on the surface of a white dwarf in a semi-detached binary system, following which some 10^-4 Msun of material, enriched in metals, is explosively ejected at ~1000km/s. Following the eruption, CNe vary rapidly, on a timescale ~months, and this necessitates continuous monitoring. Several novae were observed in GO1 as targets-of-opportunity (ToO). We propose to use the Spitzer IRS to observe a sample of novae, including GO1 ToO and several recent (<20years) CNe, to provide us with a well-populated CN parameter space. We aim to determine (i) the ejecta masses, (ii) abundances in the ejected material, (iii) evolution and processing of the CN dust.

Spitzer Space Telescope - General Observer Proposal #30077

Spitzer observations of the born-again phenomenon

Principal Investigator: Aneurin Evans
Institution: Keele University

Technical Contact: Aneurin Evans, Keele University

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Stewart Eyres, University of Central Lancashire
Victor Tyne, Keele University

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare MipsPhot
Hours Approved: 5.1

Abstract:
We propose to continue our Spitzer campaign on the ’Born Again’ phenomenon. Our goals are to (i) follow the IR evolution of the dusty and molecular shell of Sakurai’s Object, (ii) detect the effects of the star as it heats up, (iii) determine how the Aromatic Emission Features evolve from hydrogen-deficient objects to stars with normal H content, (iv) understand the origin of the mix of carbonaceous and silicate grains in the environment of O-rich binaries by observing XX Oph after it has emerged from a deep optical minimum.

Spitzer Space Telescope - General Observer Proposal #3362

In the BAG: Spitzer observations of the 'born-again' phenomenon

Principal Investigator: Aneurin Evans
Institution: Keele University

Technical Contact: Aneurin Evans, Keele University

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R. Mark Wagner, University of Arizona

Science Category: evolved stars/pn/sne
Observing Modes: IracMap IrsMap IrsStare MipsScan
Hours Approved: 16.9

Abstract:
We will use the unique capabilities of Spitzer to probe the environments of 'born-again' objects. These are evolved stars - typically of solar mass - which are on their way to becoming white dwarfs but reignite helium and retrace their evolution back up to the giant region of the H-R diagram. Spitzer will enable us to search for faint, extended far-IR fossil shells, to map out their planetary nebulae and (by combining with ongoing ground-based optical and near-IR observations), to determine the spectral energy distribution (SED) from the visible to the far-IR. Spitzer will also allow us to observe one of these systems in M31 and, because it is at a known distance, we will be able to determine unambiguously the energetics of one of these objects. These observations will help us to understand the major upheaval, only recently discovered, that is undergone by perhaps as many as 20% of solar mass stars, and hence provide us with a glimpse of what the Sun could have in store.

Spitzer Space Telescope - General Observer Proposal #40060

Spitzer observations of the post-eruption evolution of novae

Principal Investigator: Aneurin Evans
Institution: Keele University

Technical Contact: Aneurin Evans, Keele University

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Mark. T. Rushton, University of Central Lancashire

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 27.7

Abstract:
A classical nova (CN) eruption arises following a thermonuclear runaway on the surface of a white dwarf in a semi-detached binary system, following which some 10^-4 Msun of material, enriched in metals, is explosively ejected at ~1000km/s. CNe enable us to observe many astrophysical processes (such as dust formation and processing, shaping of nebulae, gas cooling by IR fine structure lines) in real time. Following the eruption, CNe vary rapidly, on a timescale ~months, and this necessitates continuous monitoring. Several novae have now been observed with Spitzer as targets-of-opportunity (ToO) and this proposal seeks further Spitzer time to continue monitoring ToO novae, and to continue monitoring the evolution of novae that erupted in the previous 20 years but before the Spitzer era. In particular, Spitzer ToO observations in previous cycles have enabled us to observe extremely dusty CNe in the mid-far for the first time. We will use the Spitzer IRS to observe novae that have erupted during the past 20 years, providing us with a well-populated parameter space. We aim to determine (i) the ejecta masses, (ii) abundances in the ejected material, (iii) evolution and processing of the CN dust. We will also continue to monitor the recurrent nova RS Oph following its 2006 eruption, and observe other recurrents during quiescence.

Spitzer Space Telescope - General Observer Proposal #40061

Spitzer observations of the stellar end-game

Principal Investigator: Aneurin Evans
Institution: Keele University

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Science Category: evolved stars/pn/sne
Observing Modes: IracMap IrsMap IrsStare MipsPhot
Hours Approved: 8.6

Abstract:
We propose to continue our Spitzer observations of the stellar end game - the demise of stars like the Sun. We will observe both carbon- and oxygen-rich examples of this stage of stellar evolution. In the former case we will continue our monitoring of Sakurai's Object as its dust shell continues to cool; we will also monitor the hydrocarbon molecules we discovered in the course of our earlier Spitzer observations of this object, to determine whether the chemistry is recent or 'frozen in'. In addition we will observe the closely-similar RCB stars, in particular those with multiple dust shells, to determine their mass-loss history. In the oxygen-rich case we will observe a 'V838 Mon-like' object in the LMC, and map its light echo.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #217

Mass Loss in Globular Clusters

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Pauline Barmby, SAO

Co-Investigators:
Brian Patten, SAO

Science Category: evolved stars/pn/sne
Observing Modes: IracMap
Hours Approved: 1.2

Abstract:
The goal of this project is to use warm circumstellar dust around globular cluster red giants as an indicator of mass loss. We will identify the giants from ground-based near-IR photometry, and identify the presence of dust with near-IR-to-IRAC colors. This will allow us to determine the mass-loss duty cycle and overall mass-loss rate. Combining the data with the results of a previous ISO study, we will calibrate the dependence of mass-loss on cluster properties such as metallicity, horizontal branch type, and structure. Mass loss is an important input to stellar population modeling, and this project will provide a much better observational calibration than has been used in the past.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30036

Inspecting infrared properties of proto- and young planetary nebulae

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Luciano Cerrigone, Harvard-CfA

Co-Investigators:
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Corrado Trigilio, INAF, Italy
Massimo Marengo, Harvard-Smithsonian Center for Astrophysics

Science Category: evolved stars/pn/sne
Observing Modes: IracMap IrsStare
Hours Approved: 9.8

Abstract:
We propose IRAC and IRS observations of a sample of proto- and young Planetary Nebulae to study stellar ejecta properties. In particular, our previous radio observations give us the possibility to compare ionized (radio detected) and non-ionized (non radio detected) envelopes in a sample of transition objects. Such a study will allow us, among other things, to investigate the effect of ionization on nebular envelopes, in relation to their chemical content and shapes.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30188

Spitzer Observations of Luminous Blue Variables

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Joseph Hora, Harvard/CfA

Co-Investigators:
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Science Category: evolved stars/pn/sne
Observing Modes: IracMap IrsStare
Hours Approved: 3.7

Abstract:
Luminous Blue Variables (LBVs) are luminous, massive stars which as they evolve from the Main Sequence to become Wolf Rayet stars, undergo a period of enhanced mass loss over a very short period of time, leading to the formation of extended circumstellar nebulae. The overall scenario of LBV evolution is still under debate and the nebula formation mechanism, including the intensity, duration and geometry of the mass-loss event, and mechanisms for producing asymmetrical distribution and differences between the gas and dust shells, is still not established. We propose to obtain IRAC images and IRS spectra of seven LBVs and candidate LBVs. The IRAC images will detect and resolve the faint dust shells that have been ejected from the central stars. In conjunction with the radio and mm data, the IRAC images will allow us to determine the SEDs of the nebula and model the gas and dust emission. The IRS spectra will show the relative importance of continuum dust emission, PAH and small grain features, possible silicate absorption and emission features, and atomic and molecular lines in the 5 - 40 μm range. These data will allow us to put together a comprehensive picture of the structure and state of the material in the nebula surrounding the LBVs, and help understand the mechanisms that have led to the asymmetrical shapes and differences between the gas and dust distributions that have been observed in these objects.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30285

Spitzer Observations of Planetary Nebulae - 2

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Joseph Hora, Harvard/Smithsonian Center for Astrophysics

Co-Investigators:
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Science Category: evolved stars/pn/sne
Observing Modes: IracMap IrsStare
Hours Approved: 10.6

Abstract:
Several interesting results have been obtained so far from our initial programs of observations of Planetary Nebulae (PNe) with Spitzer. The emission from PNe in the IRAC bands is redder than expected, due mainly to stronger than expected emission in the 8.0 ?m band due to lines of molecular hydrogen (H2) and forbidden line emission from the ionized gas. The IRAC images have detected new structures in some nebula (e.g., NGC 246) and has detected H2 emission far out in the halos of several PNe (NGC 6543, NGC 6720, NGC 7293). We are proposing several new observations to follow-up on these results. There are three categories of new observations: follow-up IRAC mapping related to previously observed PNe, follow-up IRS spectra of PNe that have been previously imaged with IRAC, and new IRAC imaging of an additional sample of PNe. These new observations will enable us to map the full extent of the large PNe observed, to determine the components of the emission detected in the IRAC images and ascertain its temperature and excitation mechanisms, and search new PNe for emission from H2 and dust in their halos.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30411

IRAC Characterization of Galactic AGB Stars

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

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Science Category: evolved stars/pn/sne
Observing Modes: IracMap IrsMap
Hours Approved: 10.8

Abstract:
We propose to observe a representative sample of well characterized AGB stars to obtain high precision IRAC absolute magnitudes and colors. The sample will explore the variation of the IRAC photometry with time, variability class, chemical type and mass loss rate. The results will be made available to the community in the form of template magnitudes and colors for each target, with the goal of helping the identification of AGB stars in already available, and future, IRAC surveys data. This will enable more detailed studies of the AGB phase as part of galactic population synthesis studies and the chemical evolution of the diffuse matter in the interstellar medium. Reliable prescriptions for discriminating AGB stars from other classes of red sources will also help other projects whose samples are contaminated by background AGB sources.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40020

The Extended Halos of Planetary Nebulae

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Center for Astrophysics

Technical Contact: Joseph Hora, Harvard-CfA

Co-Investigators:
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Howard Smith, CfA

Science Category: evolved stars/pn/sne
Observing Modes: IracMap IrsStare
Hours Approved: 5.0

Abstract:
We propose to extend our study of two planetary nebulae (PNe) by further mapping of the halo region of the Helix and Ring PNe. Our previous observations showed that the main ring of the Helix is dominated by molecular hydrogen emission. The images of these PNe show the halo extending out to and beyond the region surveyed. We propose to extend the mapping to measure the extent of the PN halo and explore the physical conditions in the outer region of the nebula. This will give clues as to the mass loss history of the star, the processing of the ejected material during the PN stage of evolution, and give clues as to the structure and formation mechanism of the PNe. We will also image the halos of several other PNe to characterize their structure.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40115

Dual dust chemistry in Wolf-Rayet Planetary Nebulae

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Center for Astrophysics

Technical Contact: Joseph Hora, Harvard-CfA

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Quentin Parker, Macquarie University Australia

Science Category: evolved stars/pn/sne
Observing Modes: IracMap IrsStare
Hours Approved: 14.9

Abstract:
Wolf-Rayet central stars of planetary nebulae are rare H-deficient stars. The mid-infrared spectra of planetary nebula central stars of late WC type ([WC8-12]) reveal dual dust chemistry: polycyclic aromatic hydrocarbons and crystalline silicates and water ice. We will use the Spitzer Space Telescope to help answer a fundamental question about planetary nebulae containing Wolf-Rayet stars: do all these nebulae show the simultaneous presence of carbon- and oxygen-rich molecules and dust in their MIR spectra, regardless of stellar spectral type, and does this phenomenon relate to the evolution of these planetaries? We will address this question through IRS low- and high-resolution spectra of the nebulae and their stars spanning the full range of Wolf-Rayet spectral types of the central stars. To interpret the nebular slit spectra we will image the PNe with IRAC in HDR mode. Well-calibrated spectra will help to understand the origin of these rare nebulae and may indicate whether evolution alone dictates their morphology, spectral energy distributions, dust band strengths, mass-loss history, and the mid-infrared spectra of their central stars.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50116

Investigating the Dust Chemistry in Pre-Planetary Nebulae

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Luciano Cerrigone, Harvard-SAO

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Science Category: evolved stars/pn/sne
Observing Modes: IracMap IrsStare
Hours Approved: 10.0

Abstract:
We propose to extend our study of young planetary nebulae/transition objects with IRAC and IRS to 1) confirm the result of the previous observations of a high (50%) incidence of dual-dust chemistry in these objects, and 2) examine a sample of objects at an earlier evolutionary state to determine the point at which the emission features arise in the shells around these objects. These data, along with ground-based high spatial resolution imaging, will provide information on the mechanisms that lead to their asymmetric shapes.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50350

Mass Loss from Classical Cepheids and their Progenitors II: IRAC Deep Search for Extended Emission

Principal Investigator: Giovanni Fazio
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Scott Engle, Villanova University

Science Category: evolved stars/pn/sne
Observing Modes: IracMap
Hours Approved: 6.4

Abstract:
Despite their importance as primary extragalactic distance indicators, there are still unresolved mysteries in the understanding and modeling of Classical Cepheids. In particular, there remains a discrepancy between measured masses and masses from evolutionary and pulsational calculations, as evidenced by recent results on Polaris. One possible explanation for this outstanding discrepancy is mass loss. Our GO-3 Spitzer observations of a sample of Classical Cepheids have revealed infrared excess around ~1/3 of our targets. This emission is spatially extended around delta Cep, SZ Tau and RS Pup, and may be the elusive evidence, missing until now, of significant mass loss through the Cepheid phase. To test how common this phenomenon is for the Cepheid phase we propose deep IRAC imaging of all the targets in our GO-3 sample. We will use these deeper and wider field images to search for further extended emission. The frequency of this emission, and the Cepheid characteristics with which it is associated (pulsation amplitude, luminosity, binarity) will provide clues to the source: ongoing mass loss or residual interstellar matter.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #68

Studying Stellar Ejecta on the Large Scale using SIRTF-IRAC

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Joseph Hora, Harvard/Smithsonian Center for Astrophysics

Science Category: evolved stars/pn/sne
Observing Modes: IracMap IrsStare
Hours Approved: 11.3

Abstract:
We will use IRAC mapping (along with MIPS images and IRS spectra) to study the stellar ejecta primarily in planetary nebulae. IRAC will map the distribution of emission from PAHs, thermal emission from dust, along with numerous atomic and molecular features from photon-dominated and shock-heated gas. These images will show the structure of the nebular shells and cool halos which will provide insight on the formation and evolution of the planetary nebulae and the ejected matter as well as information on the mass loss of the central stars.

Spitzer Space Telescope - General Observer Proposal #50256

Late time IR emission from an extremely luminous Type IIn supernova: SN 2005ip

Principal Investigator: Ori Fox
Institution: University of Virginia

Technical Contact: Ori Fox, University of Virginia

Co-Investigators:
Michael Skrutskie, University of Virginia
Roger Chevalier, University of Virginia

Science Category: evolved stars/pn/sne
Observing Modes: IracMap IrsMap
Hours Approved: 2.9

Abstract:
Near-Infrared (NIR) observations of SN 2005ip in NGC2906 reveal a Type IIn event that has remained extremely luminous (>1.6 mJy) in K-band for over two years. Type IIn supernovae have strong narrow emission lines at early times due to a dense circumstellar medium formed by the progenitor wind. The rates for Type IIn SNe indicate that the chance of a closer, brighter Type IIn event being detected within the next year is very small. While the late-time K-band emission of SN 2005ip can be attributed to warm dust, the heating source of that dust is ambiguous. SN 2005ip is unique in that it is a Type IIn event that is at the right point in its evolution for a late-time study of its IR excess. The SN is sufficiently bright and provides good IRS SNR. With just 15 minutes of integration in IRS SL1/2, spectra are capable of identifying the dust composition and disentangling the dust heating source, from which the nature of the progenitor system may also be deduced. Considering late-time emission scenarios require year long time-scales before they can be characterized, this opportunity is most likely the last for Spitzer to obtain an IRS emission spectrum of such a bright, well-sampled Type IIn event.

Spitzer Space Telescope - General Observer Proposal #30258

The hidden evolution of galactic post-AGB stars

Principal Investigator: Pedro Garcia-Lario
Institution: European Space Astronomy Centre

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Co-Investigators:
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Anibal Garcia-Hernandez, European Space Astronomy Centre

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 13.1

Abstract:
We propose to take 5-37 micron IRS spectra of heavily obscured transition objects evolving from the Asymptotic Giant Branch (AGB) to the Planetary Nebula (PN) stage. The sample contains a complete flux-limited sample selected by IRAS colors. Their strong obscuration makes them optically invisible and some of them are not even detectable in the near infrared (< 3 micron), so that they are almost inaccesible from the ground, except at millimeter and radio wavelengths. These ''hidden post-AGB'' stars are expected to represent the higher mass fraction of former AGB stars, which were not covered by previous studies of (usually optical bright) post-AGB stars. The proposed Spitzer observations will allow: a) to determine the dominant chemistry of the circumstellar shells (O-rich vs. C-rich) for a major part of the sample b) to determine the composition of the dust in terms of their structure (amorphous vs. crystalline) c) to test the ISO result that disc-like geometries of the dust are connected with large fractions of crystalline dust, and d) to identify young infrared PN and peculiar sources with mixed chemistry. We expect that the properties of the solid-state features present in the mid-infrared spectral energy distributions will allow to order the sample into an evolutionary sequence. This will be a major step to improve our understanding of the fast developing processes occuring during the''hidden phase'' of post-AGB evolution.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #122

Observations of Recent Bright Novae in Outburst

Principal Investigator: Robert Gehrz
Institution: University of Minnesota

Technical Contact: Elisha Polomski, University of Minnesota

Science Category: evolved stars/pn/sne
Observing Modes: IracMap IrsStare MipsPhot
Hours Approved: 2.7

Abstract:
We will obtain imaging and spectroscopic measurements of these novae to assess the chemical abundances of the ejecta and to image the fossil remnants of the ejecta emited during earlier phases of the evolution of the binary star system.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #130

IRAC and MIPS Maps of the Crab Nebula

Principal Investigator: Robert Gehrz
Institution: University of Minnesota

Technical Contact: Elisha Polomski, University of Minnesota

Science Category: evolved stars/pn/sne
Observing Modes: IracMap MipsPhot
Hours Approved: 2.4

Abstract:
IR images of the Crab will be made to elucidate the composition and extent of the ejecta of the supernova and to reveal the fossil winds remnants of the progenitor.

Spitzer Space Telescope - General Observer Proposal #3598

Probing the Shocked and Photoionized Ejecta in the Oxygen-Rich Supernova Remnant G292.0+1.8

Principal Investigator: Parviz Ghavamian
Institution: Johns Hopkins University

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Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 6.6

Abstract:
Of the known Galactic supernova remnants, G292.0+1.8 is the only object known to exhibit all the expected characteristics of a core-collapse SN: O-rich X-ray and optical emission from stellar ejecta, a recently discovered active pulsar and associated pulsar wind nebula, and evidence for circumstellar wind interaction. We propose IRS spectroscopy of the bright spur of shocked O-rich ejecta seen in in the optical images of G292.0+1.8 to study the nucleosynthesis products (O,Ne,...,Fe) from both hydrostatic evolution and explosive nucleosynthesis in the massive progenitor star. Recent X-ray observations suggest that only the outermost (hydrostatic product) layers have passed through the reverse shock. However, we have detected [S II] optical emission from the spur in G292.0+1.8 which may have originated in the deeper ejecta layers. The benefit of observations in the mid-IR is that nearly all of the ejecta species produce emission lines in this band, and interstellar extinction is negligible. This makes Spitzer observations the best way to bridge the gap in our understanding between the optical and X-ray results. Comparing our data with the predictions from Type II SN models we can constrain the mass of the progenitor and measure the degree of mixing between different ejecta species, critical information for understanding both the role of core collapse SNe in seeding the ISM with metals and the nature of the supernova explosion itself. We also propose a deep IRS staring observation of the center of G292.0+1.8 to detect Fe VI 19.6 micron emission from unshocked, photoionized iron. The search for Fe emission both here and in the radiative shocks will help constrain the poorly known amount of iron expelled in the SN explosion and the amount contained in the newly formed neutron star.

Spitzer Space Telescope - General Observer Proposal #40583

A Mid-IR Imaging Survey of G292.0+1.8: Mapping the Ejecta and Circumstellar Interaction

Principal Investigator: Parviz Ghavamian
Institution: Johns Hopkins University

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Science Category: evolved stars/pn/sne
Observing Modes: IracMap IrsMap MipsPhot
Hours Approved: 13.3

Abstract:
Of the known Galactic supernova remnants, G292.0+1.8 is the only object known to exhibit all the expected characteristics of a core-collapse SN: O-rich X-ray and optical emission from stellar ejecta, a recently discovered active pulsar and associated pulsar wind nebula, and evidence for circumstellar wind interaction. We propose MIPS, IRAC and IRS spectral mapping of G292.0+1.8, with the aim of (1) obtaining a consensus of the dust temperature, IR luminosity and total dust mass (CSM and ejecta) in this SNR, and (2) map the mid-IR distribution of emission from the metal-rich ejecta over the entire SNR with the goal of probing the nucleosynthetic products of both hydrostatic and explosive burning in the SN explosion. Our observations will be supported by a wealth of data including WFPC2 HST imagery, a 0.5 Ms Chandra observation, and a scheduled proper motion study with the ATCA radio array.

Spitzer Space Telescope - General Observer Proposal #50092

Dust grain processing in stable circumbinary discs around post-AGB binaries

Principal Investigator: Clio Gielen
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Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 26.7

Abstract:
Dust processing is one of the key factors in the formation of macrostructures in the circumstellar environment (CS) of stars. The most natural environment to study dust processing and its effect on the properties of the CS physics are the discs around young stellar objects. In recent years however, it became clear that dust processing is also extremely efficient in circumbinary discs around evolved objects. We have shown that these discs are common, and likely exclusively found around evolved binaries. Using IR-interferometry we have shown that the discs are very compact and remarkably stable: they must play a lead role in the evolution of the systems. Our pilot program with Spitzer showed that dust grains can be extremely processed indeed. With this follow-up program we aim to use IRS for a well selected and representative sample, both in the Galaxy and in the LMC, to investigate not only the dust characteristics of the individual objects, but also to study the evolution of the dust around these rapidly evolving objects. The program is embedded in an extensive multi-wavelength program to investigate the evolutionary processes which govern the circumstellar physics of evolved binaries as well as the impact of the stable disc on the final evolution of binary stars.

Spitzer Space Telescope - General Observer Proposal #40968

The Secret IR Lives of Cepheids: Spitzer IRS Spectroscopy of Circumstellar Envelopes, Winds and Chromospheric Emissions in Nearby Cepheids

Principal Investigator: Edward Guinan
Institution: Villanova University

Technical Contact: Edward Guinan, Villanova University

Co-Investigators:
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Nancy Evans, Harvard CfA
Graham Harper, CASA - University of Colorado at Boulder
Massimo Marenago, Harvard CfA

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 1.9

Abstract:
We are carrying out an intensive study of the physical and evolutionary properties of Classical Cepheids, known as the "Secret Lives of Cepheids" (SLiC) program. This program covers a wide range of periods and pulsation amplitudes, and makes use of X-ray/UV/optical observations. The major science goals of our proposed Spitzer program are to investigate two recently discovered characteristics of Classical Cepheids, hitherto unknown. These are the presence of circumstellar envelopes (CSEs) around three nearby Cepheids (Polaris, delta Cep and L Car - all SLiC program stars), and the existence of O VI (1032/36A) and C III (977A) emission lines in the far-UV spectra of two program stars - Polaris and beta Dor. These lines form in the chromospheres/transition regions of the Cepheids and, in the case of beta Dor, show variations that correlate to the pulsations of the star. We propose SST/IRS high-resolution spectroscopy of these four nearby, bright Classical Cepheids, three of which have been found, from long-baseline near-IR interferometry, to have CSEs ~0.5-3.0 AU from the central star. From the proposed IRS spectra, we will determine the physical characteristics of the circumstellar material/envelopes, likely arising from mass loss or, given the young ages of Cepheids, debris disks. Also, we will use the IRS spectra to explore the presence of emission lines related to those discovered in the far-UV. Possible low density He I and H I wind lines will also be measured, if present. As in the case of the FUSE far-UV observations, SST/IRS also provides the opportunity to observe and measure these emission lines at wavelengths where the Cepheid photospheric continua are very low. In the near-UV to near-IR regions, emission lines are overwhelmed by the photospheric continua. With the modest amount of time requested (~1.86-hours), the proposed IRS observations will be crucial in understanding these newly discovered characteristics of Astronomy's most important and "best-known" class of variable stars.

Spitzer Space Telescope - General Observer Proposal #20045

Understanding the Thermodynamics of late-K and early-M Supergiant Winds

Principal Investigator: Graham Harper
Institution: University of Colorado

Technical Contact: Graham Harper, University of Colorado

Co-Investigators:
Nils Ryde, Uppsala University, Sweden
Alexander Brown, University of Colorado
Matthew Richter, University of California at Davis
Fonda Day, University of Colorado
Jessica Bartley, University of Colorado

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 16.5

Abstract:
Mass loss from evolved cool stars is an important ingredient for both galactic chemical and stellar evolution, yet the mechanisms which drive mass loss remain a mystery. Most of the energy and momentum is deposited into the wind close to the star where the acceleration takes place. We propose to obtain Long- and Short High R~600, 10-37 micron spectra of a sample of late-K and early-M supergiants which probe this key spatial region, where the mass loss mechanisms will be most manifest. Emission line diagnostics will provide thermodynamic constraints on the envelopes, and provide important insights into the unknown mechanisms which heat and drive the stellar winds. These spectra will also reveal how the envelope properties change with spectral-type at the onset of dust formation in these supergiant winds.

Spitzer Space Telescope - General Observer Proposal #30737

The mass loss of S stars

Principal Investigator: Sacha Hony
Institution: Instituut voor Sterrenkunde

Technical Contact: Greg Sloan, Cornell University

Co-Investigators:
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Michael Feast, University of Cape Town, ZA
Mikako Matsuura, Queen's University of Belfast, UK
Rens Waters, University if Amsterdam, NL

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 19.7

Abstract:
We propose to perform and IRS survey of an unbiased sample of S-type AGB stars. It is expected that the dust production around those stars, with a carbon-to-oxygen ratio near unity, differs significantly from oxygen- and carbon-rich AGB stars, due to their specific abundance pattern. The objective of the survey is to determine the composition and amount of the dust that these stars produce. The S stars are not yet well covered observationally in the IR. Spitzer with its unique sensitivity allows to build an important observational dataset in a modest amount of time. The proposed observations will probe: i) How much dust is present. ii) The composition of the dust. iii) Dust mass-loss rates. iv) The dependence of the dust parameters on the stellar parameters. These observations will thus provide a complete census of S-star dusty winds. Using these results we will study the following questions: i: wind driving)} Is the amount of dust sufficient to drive a stellar wind? ii: dust condensation)} How well do we understand dust formation? The observations will provide a strong gauge point for dust condensation theory. The size of the sample (90 objects) is driven by the need to cover the range of C/O ratios from MS to CS stars, stellar temperatures and all relevant pulsations types. The total requested time amounts to 19.7 hours.

Spitzer Space Telescope - General Observer Proposal #3345

detached_shells_carbon_stars

Principal Investigator: Sacha Hony
Institution: ESTEC/European Space Agency

Technical Contact: Sacha Hony, Instituut voor Sterrenkunde

Co-Investigators:
Laurens Waters, University of Amsterdam, The Netherlands
Jeroen Bouwman, Max Planck Institute fur Astrophysik, Germany

Science Category: evolved stars/pn/sne
Observing Modes: IrsMap IrsStare
Hours Approved: 2.5

Abstract:
We propose to obtain 19-37 micrometer IRS spectra of the detached shells around nearby carbon-stars. We have selected a small (11) sample of bright, well studied, carbon-stars with known detached shells. The sample covers a range of angular diameters of the detached shells from 8-200" and stellar effective temperatures between 800-2600 K. With the spectra of the dust in the detached shell we aim to establish: i) The location of the shell. ii) The chemistry of the shell in order to constrain it's origin. iii) Test the MgS identification for the ''30'' micrometer emission feature. iv) Determine observationally the relationship between the ''30'' micrometer feature peak-position and the distance to the star. These observations will contribute greatly to the understanding AGB-star mass loss, in general, and the phenomenon of detached shells around carbon-stars, in particular. They will also be used to develop a diagnostic tool that allows to study detached shell properties of distant carbon-stars, that cannot be spatially resolved, based on their IR spectrum alone. The total requested time is 2.5h.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #133

Anomolous X-ray Pulsars

Principal Investigator: James R. Houck
Institution: Cornell University

Technical Contact: Sarah Higdon, Cornell University

Science Category: evolved stars/pn/sne
Observing Modes: IracMap MipsPhot
Hours Approved: 2.0

Abstract:
We aim to understand the physics and astrophysics of magnetars in order to establish the diversity in young neutron-star properties, as well as the behaviour of matter in the strongest magnetic fields known. Magnetar research is in an early exploratory stage, necessarily phenomenological, in which basic magnetar properties are just being established. Magnetars come in two flavours: soft-gamma repeaters (SGRs) and anomalous X-ray pulsars. This program selects a sample of AXPs. We are just beginning to map out AXP near-IR properties. Spitzer offers the unique opportunity to determine the mid-IR SED through combined IRAC 4.5um & 8um and MIPS 24um observations. The resulting mid-IR SEDs will be used to constrain theorys for the origin of the IR emission.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30332

Spectroscopy of Thin Dust Shells in the Magellanic Clouds

Principal Investigator: James R. Houck
Institution: Cornell University

Technical Contact: Greg Sloan, Cornell University

Co-Investigators:
Gregory Sloan, Cornell University
Daniel Devost, Cornell University
Jeronimo Bernard-Salas, Cornell University
Peter Wood, Australian National University
Jacco van Loon, Keele University

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 6.4

Abstract:
This program will use the IRS to re-observe four optically thin oxygen-rich dust shells in the Magellanic Clouds first observed in the MC_DUST program, which was part of the IRS GTO allocation. Several sources in the MC_DUST program show either no dust emission or a dust excess too weak with respect to the noise to properly characterize with any confidence. We propose to follow-up four of these sources that show evidence for unusual emission with longer integrations, both in SL and LL. One source in the SMC, which we have confirmed to be an S star, shows unusual molecular absorption and possible emission at 13 and/or 14 microns. Two sources show evidence for pyroxene dust emission, which would be highly unusual for optically thin circumstllar dust shells. Another source is a candidate for alumina dust emission, which we have confirmed in only one other spectrum in our sample so far. Alumina is believed to be precursor to silicates as dust shells begin to form around evolved stars. Lower abundances of Al with respect to O, Mg, Si, and Fe would be a natural explanation for the apparent lack of alumina dust in the Magellanic Clouds, but a selection effect might also play a role, as most of the sources observed are bright and red and more likely to be surrounded by silicate dust. We need to obtain spectra with better sensitivity among the low-contrast dust sources before we can discount a selection effect.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30345

High-resolution Spectroscopy of Apparent 14 Micron Features

Principal Investigator: James R. Houck
Institution: Cornell University

Technical Contact: Greg Sloan, Cornell University

Co-Investigators:
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Daniel Devost, Cornell University
Jeronimo Bernard-Salas, Cornell University
Kathleen Kraemer, Air Force Research Laboratory
Peter Wood, Australian National University
Jacco van Loon, Keele University

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 0.8

Abstract:
The IRS has detected an apparent 14 micron emission feature in the spectra of several silicate dust sources in the Magellanic Clouds. The detections were made using the low-resolution modules, and the feature lies right on the boundary between SL and LL. We have ruled out any known mechanism which could produce a spectral artifact at this wavelength. While the feature is probably real, its detailed structure, which differs among various sources, could be affected by instrumental behaviour. We have chosen three sources showing different structure in the 14 micron region, and we propose to follow these up using the SH module to (1) confirm the existence of the 14 micron feature, (2) quantify its shape, and (3) attempt to identify its carrier. This program will only take 0.8 hours, and in return we will be able to confirm the existence of a previously unidentified dust feature and possibly identify a new dust component as well.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30355

Spectroscopy of Crystalline Silicates in the SMC

Principal Investigator: James R. Houck
Institution: Cornell University

Technical Contact: Greg Sloan, Cornell University

Co-Investigators:
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Daniel Devost, Cornell University
Jeronimo Bernard-Salas, Cornell University
Kathleen Kraemer, Air Force Research Laboratory
Peter Wood, Australian National University
Jacco van Loon, Keele University
Alberto Bolatto, University of California at Berkeley
Joshua Simon, California Institute of Technology

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 1.3

Abstract:
We propose IRS observations of four evolved stars in the Small Magellanic Cloud with infrared colors indicating the presence of crystalline silicate dust grains in their spectra. Spectra produced by crystalline silicates make it possible to study the astromineralogy of dust grains, specifically compositional details like olivine/pyroxene ratio and Mg/Fe ratio and the size and shape distribution. By observing the SMC, with its metal-poor nature compared to the Milky Way and even the LMC, we can examine how metallicity affects the formation and composition of circumstellar dust grains. This 1.3 hour program will observe four sources, adding to the small sample of three SMC sources known to have crystalline silicates in their spectra and improving our ability to intercompare samples from the two Magellanic Clouds and the Galaxy. These comparisons will help us understand how grain properties vary with metallicity.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30482

Infrared-Mapping of the extended planetary nebulae NGC2392 and NGC2346

Principal Investigator: James R. Houck
Institution: Cornell University

Technical Contact: Jeronimo Bernard-Salas, Cornell University

Co-Investigators:
Els Peeters, SETI
John-David Smith, Steward Observatory
Greg C. Sloan, Cornell University
Stuart R. Pottasch, Kapteyn Astronomical Institute

Science Category: evolved stars/pn/sne
Observing Modes: IrsMap
Hours Approved: 7.1

Abstract:
We propose a pilot spectroscopic study of the extended PNe NGC2392 (classical spherical), and NGC2346 (classical bipolar) using the IRS spectrograph on board Spitzer. The analysis will be done using CUBISM, a tool developed for constructing spectral cubes, maps, and arbitrary aperture 1D spectral extractions from IRS data. The main goal of this proposal is to study the ionization structure of a PN and test whether the assumptions of homogeneity often used in the literature is valid, and to study the spatial behavior of dust features across an extended planetary nebula. This pilot study will be of great value for the interpretation of observations of the abundances and PAH emission features in the wide range of objects that are known to show these bands both in the near universe and in galaxies far away.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30550

Revealing the nature of Bulge Planetary Nebulae

Principal Investigator: James R. Houck
Institution: Cornell University

Technical Contact: Jeronimo Bernard-Salas, Cornell University

Co-Investigators:
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Greg C. Sloan, Cornell University
Patrick W. Morris, NASA Herschel Center

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 5.0

Abstract:
We propose observing a sample of 11 bulge planetary nebulae using the IRS spectrograph on board Spitzer. The goal is to study their chemical composition and physical parameters in order to understand their nature and evolution. Because of their brightness bulge planetary nebulae are ideal to study the dynamics of the Galaxy and their abundances can be used to determine the metallicity gradient toward the Galactic Center. Despite their importance, the nature of these objects is still not well understood. For instance, do the bulge planetary nebulae belong to an old population or are they part of a population with recent star formation? One way to study this problem is by simply deriving the abundances of certain elements, like sulfur and argon. These elements are neither produced nor destroyed in the course of evolution and therefore represent the composition at the time of star formation. Abundance determination of these elements have been attempted but sulfur and argon emit most of their lines in the IR, and therefore optical or UV studies have been inconclusive. Spitzer posseses the ideal wavelength coverage to obtain accurate abundances for these elements and give a good insight in the evolutionary and nucleosynthesis properties of the stellar progenitors. Moreover, it's sensitivity allows one to observe these objects in very short integration times, and for the first time have a look into the dust of these objects in a metal--rich environment in our own Galaxy. In the same framework of study we have included in this sample a very interesting PN (NGC3132) which doesn't belong to the bulge but which shows very unusual characteristics. This unusual behavior should be studied in the infrared, both to study the dust and to account for unseen ions to derive accurate abundances. Spitzer's spectra will be of invaluable value obtain a consistent theoretical evolutionary picture of these objects.

Spitzer Space Telescope - General Observer Proposal #20208

21 and 30 Micron Emission Features in Post-AGB Circumstellar Envelopes

Principal Investigator: Bruce Hrivnak
Institution: Valparaiso University

Technical Contact: Bruce Hrivnak, Valparaiso University

Co-Investigators:
Kevin Volk, Gemini Observatory
Sun Kwok, Institute of Astronomy and Astrophysics, Taiwan

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 1.5

Abstract:
We propose to obtain IRS HL and HS spectra of the unidentified 21 micron feature and the recently resolved 30 (27+34) micron feature in eight carbon-rich proto-planetary nebulae. For four of these, we have previously detected the 21 micron feature but at low S/N, and in the other four, we predict its presence. ISO spectra had detector problems at 27 microns, which make the exact shape of the two 30 micron components somewhat uncertain. These observations will greatly assist in the identification of the carriers of these features and provide important insights into the circumstellar chemistry in this carbon-rich and transient environment. The spectral energy distributions will be modeled, and from these the density profiles and mass-loss rates will be determined, along with the feature shapes and strengths.

Spitzer Space Telescope - General Observer Proposal #30403

Spitzer Search for the 21 Micron Sources from the MSX PSC Catalog

Principal Investigator: Biwei Jiang
Institution: Beijing Normal University

Technical Contact: Biwei Jiang, Beijing Normal University

Co-Investigators:
Aigen Li, University of Missouri-Columbia
Ke Zhang, Beijing Normal University

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 2.3

Abstract:
The identity of the prominent 21 micron feature seen in protoplanetary nebulae (and possibly also in extreme AGB stars and PNe) is one of the most interesting unresolved mysteries in astrochemistry (cf. Kwok, Volk, & Hrivnak 2002, ApJ, 573, 720). Although a variety of carriers have been proposed to explain this enigmatic dust feature, it still remains unidentified since its discovery in 1989, partly due to the scarcity of such sources. To enlarge the ‘‘21 micron’’ source sample, we propose to search for new 21 micron sources, mainly based on the Midcourse Space Experiment (MSX) Point Source Catalog. Since the MSX Band E centers at 21 micron, the excess in this band might indicate the existence of the 21 micron emission. In combination with the IRAS mimic colors of late-type stars and the 21 micron sources, we selected 18 candidate objects for the 21 micron emission. We propose to use the Spitzer IRS spectrograph to take high resolution spectra of these objects to search for new 21 micron sources. This will greatly help characterize the physical and chemical conditions for the existence of this mysterious feature.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #20

A Study of the Red Rectangle

Principal Investigator: Michael Jura
Institution: University of California - Los Angeles

Technical Contact: Michael Jura, University of California - Los Angeles

Science Category: evolved stars/pn/sne
Observing Modes: IrsMap IrsStare
Hours Approved: 2.8

Abstract:
A study of the Red Rectangle.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #23

Searching for Dust Disks Around Pulsars

Principal Investigator: Michael Jura
Institution: University of California - Los Angeles

Technical Contact: Michael Jura, University of California - Los Angeles

Science Category: evolved stars/pn/sne
Observing Modes: IracMap IrsStare MipsPhot
Hours Approved: 14.4

Abstract:
This program will search for dust disks around pulsars with the goal of trying to see if these objects have environments where planets might form.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #9

Dust Around First Ascent Red Giants

Principal Investigator: Michael Jura
Institution: University of California - Los Angeles

Technical Contact: Michael Jura, University of California - Los Angeles

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare MipsPhot
Hours Approved: 4.3

Abstract:
We propose to use MIPS to measure the dust around first ascent red giants which show infrared excesses in the IRAS data base. Our goal is to infer the mass, spatial distribution and temperature of the particles with the hope of inferring their origin. We chose stars that lie within 150 pc of the Sun that display an excess at 60 microns of at least 0.5 Jy and lie at absolute Galactic latitude greater than 10.

Spitzer Space Telescope - General Observer Proposal #40619

Spitzer Studies of Supernova ejecta and dust

Principal Investigator: Rubina Kotak
Institution: Queen’s University Belfast

Technical Contact: Rubina Kotak, Queen’s University Belfast

Co-Investigators:
Christopher Gerardy, Imperial College London
Peter Meikle, Imperial College London
Anja Andersen, Copenhagen University
Duncan Farrah, Cornell University
Alex Filippenko, University of California at Berkeley
Ryan Foley, University of California at Berkeley
Peter Hoeflich, Florida State University
Peter Lundqvist, Stockholm Observatory
Seppo Mattila, Queen’s University Belfast
Monica Pozzo, University College London
Jesper Sollerman, Stockholm Observatory
Schuyler van Dyk, Spitzer Science Center
Craig Wheeler, University of Texas

Science Category: evolved stars/pn/sne
Observing Modes: IracMap IrsPeakupImage IrsStare MipsPhot
Hours Approved: 49.8

Abstract:
We propose to continue our successful mid-infrared studies of supernovae (SNe). Our first goal is to investigate the hypothesis that core-collapse supernovae (CCSNe) are, or have been, major producers of cosmic dust. Warm grains emit most strongly in the mid-IR which is the ideal wavelength range for following dust condensation in real time. Alternatively, infrared light echoes may arise from pre-existing dust in the circumstellar medium created by mass loss from the progenitor. Discrimination between new dust condensing in supernova ejecta and pre-existing dust can be deduced from the mid-IR spectral energy distribution and evolution. By combining photometric and spectral data from Spitzer, we have been able to show that dust is probably condensing in 3 of our SN IIP targets. This constitutes the first real evidence that dust does condense in the ejecta of typical CCSNe. In GO4, we propose to establish the location and composition of the dust, using the full suite of Spitzer instrumentation. Our second, but equally important goal, is to test explosion models for SNe by measuring the intensity and, where feasible, the evolution of late-epoch fine-structure lines and molecular features. We are testing explosion-model-sensitive predictions of abundances. Our first results have already demonstrated the power of Spitzer spectroscopy: we have achieved the first-ever mid-IR detections of type Ia SNe. From this, we deduced that that the ejecta exhibit significant chemical stucture and show signs of large deviations from spherical symmetry. We also detected the first incidence (since SN1987A) of molecular emission from SiO in a CCSN. Our late-time measurements of stable Nickel have constrained progenitor masses and metallicities. Our programme has already resulted in many "firsts", and we wish to utilise the remaining lifetime of Spitzer to build up these results into a broader picture of the properties of SNe in the mid-IR, and address issues that cannot be tackled at other wavelengths.

Spitzer Space Telescope - Directors Discretionary Time Proposal #471

Mid-infrared observations of a bright, new, thermonuclear supernova in the Antennae Galaxy

Principal Investigator: Rubina Kotak
Institution: Queen's University Belfast

Technical Contact: Rubina Kotak, Queen's University Belfast

Co-Investigators:
Schuyler Van Dyk, Spitzer Science Center
Chris Gerardy, Florida State U.
Peter Meikle, Imperial College London

Science Category: evolved stars/pn/sne
Observing Modes: IracMap MipsPhot IrsStare
Hours Approved: 2.1

Abstract:
The discovery of the new, bright, type Ia supernova, SN 2007sr in the interacting galaxy pair, NGC 4038 offers a unique opportunity to study a type Ia supernova (SN) in an extreme environment. The occurrence of such an event during the remaining cryogenic lifetime of Spitzer is unlikely, so we request DDT observations with the full suite of Spitzer instrumentation. We will use the wealth of diagnostics afforded by the mid-IR fine-structure lines to infer the location and kinematics of the nucleosynthesised material. Through our previous Spitzer programmes, we are gradually building up a sample -- still relatively small -- of mid-IR observations of SNe. This will ultimately allow to understand the diversity of observed behaviour. SN 2007sr is likely to generate enormous interest in the wider community, and our proposed Spitzer observations will play a key role in piecing together the evolutionary history for this unique SN.

Spitzer Space Telescope - General Observer Proposal #20381

Study of relativistic filaments near the supernova remnant Cassiopeia A

Principal Investigator: Oliver Krause
Institution: University of Arizona

Technical Contact: Oliver Krause, University of Arizona

Co-Investigators:
George H. Rieke, University of Arizona
Stephan M. Birkmann, Max-Planck-Institut fur Astronomie
Emeric Le Floc'h, University of Arizona
Dean C. Hines, Space Science Institute
William B. Latter, Spitzer Science Center
Alberto Noriega-Crespo, Spitzer Science Center

Science Category: evolved stars/pn/sne
Observing Modes: IrsMap MipsScan
Hours Approved: 20.3

Abstract:
Two 24 micron Spitzer images with 1 year time difference have revealed a bipolar moving structure emanating from the main shell of the young supernova remnant Cassiopeia A and extending more than 20 arcmin from its kinematical center. Large motions of order 10 to 20 arcsec have been observed for individual filaments in these mid-infrared images, indepen- dently confirmed by three epochs of ground-based near-infrared observations towards the northern lobe of the structure. Assuming the standard distance to the supernova remnant, 3.4 kpc, the observed tangential velocities are at roughly the speed of light. Motions with this speed have never been observed in any supernova remnant. They are presumably associated with central activity in the SNR such as a relativistic jet. If so, they may have a profound impact on our understanding of the astrophysics in supernovae. For example, they may help identify Cas A as a local site of a gamma ray burst. Although photometric measurements between 2.2 and 24 micron indicate an underlying thermal continuum towards the relativistic filaments, their emission mechanism and true extent is still unknown. We propose a detailed study of these enigmatic objects with Spitzer: I) We wish to extend our map to search for moving features out to the full speed-of-light radius, reached by light leaving the SNR at the time of the explosion 325 years ago. These maps will constrain possibilities for the origin and maintenance of the features. II) IRS spec- troscopy of a bright knot will provide information on the emission mechanism of the features by examining the continuum behavior and searching for any emission lines to a high level of sensitivity. III) We propose to observe the well-studied relativistic jet source SS433 and the Crab-Nebula, the second youngest unambiguous type II supernova remnant in our Galaxy, to test whether relativistic filaments are also detected there.

Spitzer Space Telescope - Directors Discretionary Time Proposal #231

Spitzer imaging of a superluminal jet from the supernova remnant Cassiopeia A

Principal Investigator: Oliver Krause
Institution: University of Arizona

Technical Contact: Oliver Krause, University of Arizona

Co-Investigators:
George Rieke, U. Arizona
Dean Hines, U. Arizona
Emeric Le Floc'h, U. Arizona

Science Category: evolved stars/pn/sne
Observing Modes: IracMap MipsScan
Hours Approved: 0.9

Abstract:
We propose to use 55 min of Spitzer Director's Discretionary Time to perform MIPS and IRAC follow-up observations of a remarkable bipolar structure around the type II supernova remnant Cassiopeia A, which was serendipitously discovered during MIPS 24 micron early release observations. Two epochs of recently obtained K-band images towards the northern lobe of this structure revealed strong time variations and proper motions of up to 6" within only 4 months, which are among the fastest ever observed for an object beyond the solar system. Assuming these phenomena are physically connected to the supernova remnant at a distance of 3.4 kpc, the observed tangential velocities are at luminal or superluminal speed. In our galaxy, (super)luminal motios have so far only been observed in light echos and relativistic jets of microquasars. We propose to repeat the MIPS 24 micron scan map of Cas A in the upcoming visibility window in order to follow-up the high proper motions observed in the K-band. Contemporary images of the bright northern lobe in the four IRAC bands between 3.6 and 8 microns with a third epoch of K-band observations in early December will reveal important clues about the physical nature of the mechanism (thermal/non-thermal) of the observed infrared emission.

Spitzer Space Telescope - Directors Discretionary Time Proposal #233

Spitzer reobservation of a superluminal jet from the supernova remnant Cassiopeia A

Principal Investigator: Oliver Krause
Institution: University of Arizona

Technical Contact: Oliver Krause, University of Arizona

Co-Investigators:
Karl Gordon, U. Arizona
George Rieke, U. Arizona
Dean Hines, U. Arizona
Emeric Le Floc'h, U. Arizona

Science Category: evolved stars/pn/sne
Observing Modes: MipsScan
Hours Approved: 2.6

Abstract:
We request 6.75 hours of Spitzer Director's Discretionary Time to perform MIPS observations of a remarkable moving structure emanating from the type II supernova remnant (SNR), Cassiopeia A. The structure was serendipitously discovered during MIPS 24 microns early release observations. A repeat observation obtained one year later under Director's Discretionary Time showed large motions, of order 10 to 20 arcsec, with a systematic trend for the motions to be to outward from the SNR. Four epochs of deep K-band images towards the northern lobe of this structure also reveal strong time variations and proper motions. Assuming the standard distance to the supernova remnant, 3.4kpc, the observed tangential velocities are at luminal to superluminal speed. They are presumably associated with central activity in the SNR such as a relativistic jet. If so, they may have a profound impact on our understanding of the astrophysics in supernovae. For example, relativistic jets in core collapse supernovae are considered as the most likely origin of gamma ray bursts.

Spitzer Space Telescope - General Observer Proposal #20049

Abundances in Halo Planetary Nebulae: Was/Is the Galactic Halo Chemically Inhomogeneous?

Principal Investigator: Karen B. Kwitter
Institution: Williams College

Technical Contact: Karen B. Kwitter, Williams College

Co-Investigators:
Richard B.C. Henry, U. Oklahoma
Reginald Dufour, Rice U.

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 8.3

Abstract:
The chemical history of the Galactic halo, currently poorly understood, is a critical piece in the puzzle of understanding how the Milky Way and other spiral galaxies have formed and evolved. Stellar spectroscopy studies of halo stars have revealed large abundance variations, sparking various speculations to explain the observed scatter. Halo planetary nebulae (PNe) offer a complementary and independent method of assessing halo chemical composition. The goal of this project is to derive accurate chemical abundances for six halo PNe, including two with extremely interesting abundance profiles, and in so doing, to help evaluate theories of Galactic halo formation and enrichment already motivated by the stellar abundance studies. We propose to obtain IRS spectra of six halo PNe from 6-36 microns to detect emission lines of important elements (including Ne, S and Ar) arising from ionization states that are difficult or impossible to observe from the ground. We will explore the implications of inaccuracies that result from the current necessary practice of applying an empirical "ionization correction factor" to account for the contribution from unobserved ions.
Results from the proposed observations, combined with our ground-based spectroscopy already in hand, will lead to: 1) improved understanding of what is necessary for accurate determination of abundances in PNe, particularly for Ne, Ar and S, and 2) deeper insight into the complex pattern of chemical elements in the halo already seen to be exhibited by stars.

Spitzer Space Telescope - General Observer Proposal #50212

Dust in R Coronae Borealis stars

Principal Investigator: David Lambert
Institution: University of Texas, Austin

Technical Contact: David Lambert, University of Texas, Austin

Co-Investigators:
N. Kameswara Rao, Indian Institute of Astrophysics
D. Anibal Garcia-Hernandez, Instituto de Astrofisica de Canarias (IAC)

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 3.1

Abstract:
R Coronae Borealis stars (RCBs) provide an unique circumstellar environment that is hydrogen-deficient, helium-rich and carbon-rich in which dust condensation occurs. Litle is known about how and where the dust condensation process, compositions of the dust, and the trigger for dust formation. The hydrogen-poor carbon-rich and metal-poor (in some cases) character of the gas may facilitate the formation of dust species which are not seen in the interstellar medium or in envelopes of normal stars. Spitzer/IRS spectroscopy offers a great opportunity to characterize the infrared spectra of RCBs. Surprisingly, Spitzer has not systematically observed a complete sample of RCB stars in the previous four cycles and, thus, a comprehensive study of these dusty and fascinating stars is at present lacking. Completely inadequate spectra have been obtained from ground-based telescopes, even after nearly four decades since the discovery of the IR excess of RCB stars. We propose to obtain a library of Spitzer/IRS spectra of 18 RCB stars. Our goal is to observe stars across the chemical composition range observed in RCBs and to extend observations to the coolest RCB stars. These spectra will be complemented with the existing Spitzer/IRS spectra of 12 warmer RCB stars, creating a complete sample of 30 RCBs observed with Spitzer. Present knowledge of the dust features in RCBs depends on our previous ISO spectra of the 3 brightest RCB stars in the 3 to 25 micron region. A representative inventory of infrared spectra and dust features in our complete sample of RCB stars will provide important clues to the composition and dust formation process in these unique stars.

Spitzer Space Telescope - General Observer Proposal #20130

Searching for the Donor Star in Close Binary Supersoft Sources

Principal Investigator: Thierry Lanz
Institution: University of Maryland

Technical Contact: Thierry Lanz, University of Maryland

Co-Investigators:
Marc Audard, Columbia University
Ivan Hubeny, Steward Observatory
Frits Paerels, Columbia University

Science Category: evolved stars/pn/sne
Observing Modes: IracMap IrsStare MipsPhot
Hours Approved: 9.4

Abstract:
The identification of Type Ia Supernova progenitors still remains elusive. The most promising channel to form SNe Ia involves accreting white dwarfs (WDs) in close binary systems. The hot WDs sustain steady nuclear burning and are observed as ultrasoft X-ray sources. The companions have remained until now undetected because the UV and optical spectrum is dominated by the emission from the accretion disk around the WDs. At present, these close binary supersoft sources (CBSS) have not been observed in the infrared, with the single exception of near-IR photometry of the Galactic CBSS QR And that provides the first hint of the secondary. Because of the general lack of a direct detection, the nature of the donor stars in these systems is still debated. By combining ultraviolet and optical SEDs with Spitzer observations of 4 CBSS in the mid-infrared, we will be able to definitively identify the nature of the donor stars in CBSS systems, as well as determining the size of the accretion disks. We propose to observe eclipsing systems at different phases to disentangle the contribution of the companions from the emission of the disks. Spitzer observations of CBSS will therefore represent a significant step forward in characterizing the binary systems that are best candidates for becoming SNe Ia.

Spitzer Space Telescope - General Observer Proposal #3373

Revealing the Nature of Mass Loss in Globular Cluster Stars

Principal Investigator: Thomas Lebzelter
Institution: University of Vienna

Technical Contact: Thomas Lebzelter, University of Vienna

Co-Investigators:
Kenneth Hinkle, NOAO
Thomas Posch, University of Vienna

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 12.9

Abstract:
The formation of dust plays a key role in the mass loss from stars during their final evolutionary stages. We propose to investigate the composition of dust around AGB stars in the Globular Cluster NGC 104 using IRS. The AGB stars of our sample are well defined concerning their mass, luminosity, metallicity and variability. Our results will not only provide insight into the dust composition in a metal poor environment, but will also allow dust characteristics to be linked with the evolutionary stage along the AGB. Furthermore we will investigate the role of stellar pulsation on the dust forming and mass loss process. Finally, knowing the composition of the dust may help to understand why globular clusters appear to have so little inter-cluster dust.

Spitzer Space Telescope - General Observer Proposal #50346

Mass Loss from Classical Cepheids and their Progenitors II: Spatially Resolved Spectra of Extended Emission

Principal Investigator: Massimo Marengo
Institution: Harvard-Smithsonian Center for Astrophysics

Technical Contact: Massimo Marengo, Harvard-SAO

Co-Investigators:
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Pauline Barmby, University of Western Ontario
Doug Welch, McMaster University
Giuseppe Bono, INAF Oss. Astronomico di Roma
Martino Romaniello, ESO
Edward Guinan, Villanova University
Scott Engle, Villanova University

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 14.5

Abstract:
Despite their importance as primary extragalactic distance indicators, there are still unresolved mysteries in the understanding and modeling of Classical Cepheids. In particular, there remains a discrepancy between measured masses and masses from evolutionary and pulsational calculations, as evidenced by recent results on Polaris. One possible explanation for this outstanding discrepancy is mass loss. Our GO-3 Spitzer observations of a sample of Classical Cepheids have revealed infrared excess around ~1/3 of our targets. This emission is spatially extended around delta Cep, SZ Tau and RS Pup, and may be the elusive evidence, missing until now, of significant mass loss though the Cepheid phase. To confirm this hypothesis, we propose to obtain IRS spectral maps in key positions around the three Cepheids where the emission was spatially resolved by Spitzer. These observations will clarify the nature and composition of the circumstellar material, and discriminate between its two possible origins: ongoing mass loss or residual interstellar matter.

Spitzer Space Telescope - General Observer Proposal #50338

Astrochemistry and Astromineralogy at Low Metallicity

Principal Investigator: Mikako Matsuura
Institution: University of Manchester

Technical Contact: Mikako Matsuura, University of Manchester

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You-Hua Chu, University of Illinois at Urbana-Champaign
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Kathleen Kraemer, Air Force Research Lab
Eric Lagadec, University of Manchester
Quentin Parker, Macquarie University
Warren Reid, Macquarie University
Greg Sloan, Cornell University
Kevin Volk, Gemini Observatory
Peter Wood, Australian National University
Albert Zijlstra, University of Manchester

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 17.2

Abstract:
We propose to investigate the mineralogy and chemistry of dust around low-metallicity extragalactic post-asymptotic giant branch (AGB) objects. The way simple hydrocarbons such as acetylene (C_2H_2) (which are observed around the AGB stars) arises, their transition into more complex molecular forms such as polycyclic aromatic hydrocarbons (PAHs) and other dust particles (common in reflection nebulae, star forming regions (SFRs), and planetary nebulae), are still poorly understood. Recent infrared observations of post-AGB sources, however, suggest that these objects, in transition from the AGB to PNe, may play a key role in our understanding of the dust chemistry, as well as elucidating an elusive phase of stellar evolution. With the Infrared Spectrograph on Spitzer, we will observe a selection of known post-AGB objects and infrared-selected candidates to explore the evolution of molecules from simple to complex hydrocarbons to small dust grains.

Spitzer Space Telescope - General Observer Proposal #30616

Measuring the Mass and Spin of a Stellar Black Hole

Principal Investigator: Jeffrey McClintock
Institution: Harvard-Smithsonian Center for Astrophysics

Technical Contact: Tom Megeath, Harvard, CfA

Co-Investigators:
Jerome Orosz, San Diego State University
Charles Bailyn, Yale University
Michael Muno, University of California, Los Angeles
Danny Steeghs, Harvard-Smithsonian Center for Astrophysics
Thomas Megeath, Harvard-Smithsonian Center for Astrophysics
Ronald Remillard, Massachusetts Institute of Technology
Rebecca Shafee, Harvard University
Ramesh Narayan, Harvard-Smithsonian Center for Astrophysics

Science Category: evolved stars/pn/sne
Observing Modes: IracMap
Hours Approved: 15.8

Abstract:
We propose to obtain reliable and precise mass measurements for two black holes, A0620-00 and X-ray Nova Mus 1991, and to estimate the spin of the latter. In order to succeed, we must explore the properties of the cold accretion disks that surround these quiescent black holes. Although the study of these cold disks is a secondary objective, it is one of fundamental importance that may have decisive impacts on other areas of astrophysical research. With IRAC we propose to obtain complete orbital light curves of both binary black holes in all four passbands at high time resolution. Our modeling of these light curves will allow us to separate the disk and stellar components of light and thereby measure black hole mass and spin and also secure the first direct measurements of these inviscid black-hole disks. Spitzer observations are crucially important because no other space or ground-based observatory can make direct observations of these cold accretion disks.

Spitzer Space Telescope - General Observer Proposal #50582

Mass Loss from Jet Symbiotics and Their Role as Type Ia Supernova Precursors

Principal Investigator: Bruce McCollum
Institution: Spitzer Science Center

Technical Contact: Bruce McCollum, Spitzer Science Center

Co-Investigators:
Frederick Bruhweiler, CUA/IACS
Glenn Wahlgren, CUA/IACS
Meyer Pesenson, SSC

Science Category: evolved stars/pn/sne
Observing Modes: IracMap
Hours Approved: 4.7

Abstract:
Using Spitzer data, we have discovered a large (~5 arcmin) bright unipolar lobe ejected from the classical symbiotic binary system, BI Cru, the only such IR lobe known associated with any symbiotic. BI Cru is a member of the recently-discovered subset of symbiotics which have jets. It is also the only symbiotic imaged by Spitzer which is a 'jet symbiotic'. It is thus important to use Spitzer to study other jet symbiotics. We will use Spitzer IR imagery to identify other extended warm and cool ejecta around the remaining known jet symbiotics. Our goal is to use Spitzer imagery of the environs of these stellar binaries to: a.) search for and delineate the stellar ejecta produced, via collimated outflows (jets), and outbursts, around these objects, b.) determine whether such large ejecta as with BI Cru are correlated with the presence of jets, c.) use these data to estimate total ejecta masses, and d.) use these results to constrain the mass accretion efficiency and what fraction of WDs actually reaches the Chandrasekhar mass and detonate as Type Ia supernovae. An absence of detected ejecta would constrain the past mass loss. This study could have profound implications for the energy input into galaxies and to chemical enrichment of elements like Fe, that originate in SN Ia explosions.

Spitzer Space Telescope - General Observer Proposal #20256

Infrared Study of Supernova Ejecta and Dust

Principal Investigator: W. Peter Meikle
Institution: Imperial College London

Technical Contact: W. Peter Meikle, Imperial College London

Co-Investigators:
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Peter Lundqvist, University of Stockholm
Craig Wheeler, University of Texas
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Claes Fransson, University of Stockholm
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Jesper Sollerman, University of Stockholm
Schuyler Van Dyk, Spitzer Science Center
Alex Filippenko, U. California at Berkeley
Ryan Foley, U. California at Berkeley

Science Category: evolved stars/pn/sne
Observing Modes: IracMap IrsPeakupImage IrsStare
Hours Approved: 46.8

Abstract:
We propose to continue and to enhance our IRAC/IRS program aimed at gaining powerful new insights on the nature of supernova (SN) explosions and testing the hypothesis that SNe are major sources of cosmic dust. We would observe up to 17 SNe over a wide range of post-explosion epochs. Our first goal is to test SN explosion models by measuring the intensity and, where possible, the evolution of fine-structure (FS) lines and molecular features. By comparison with our spectral synthesis models we shall test explosion-model-sensitive predictions of abundances. Most of the FS lines arise from ground state transitions and so, in comparison with optical/near-IR spectra, are much less sensitive to temperature and density uncertainties. However they are only accessible in the mid-IR, and provide the most useful abundance measurements at late times when the ejecta are optically thin. Ground-based mid-IR observations at such late epochs are almost impossible. In GO1 we have already discovered an FS line of [CoIII] in a Type Ia SN. [AIII], [SIV] and [CoII] FS lines are probably also present. We have detected a strong [NiII] FS line and CO fundamental emission in a core-collapse SN (CCSN). Apart from SN 1987A, this is the first time that such features have been observed in any SN. Our second goal is to investigate CCSNe as the major source of dust in the universe, past or present. Direct evidence in support of this is still very sparse. Warm grains emit most strongly in the mid-IR, and so is the ideal wavelength range for following dust condensation in the ejecta or possibly in a cool, dense shell at the ejecta/progenitor wind interface. Alternatively, such radiation may arise from IR light echo emission from progenitor-wind dust. Discrimination between condensing dust and pre-existing circumstellar dust can be deduced from the mid-IR spectral energy distribution and evolution. Our IRAC data have already provided evidence of dust IR emission in two CCSNe. In one case, new grain condensation is indicated.

Spitzer Space Telescope - General Observer Proposal #3248

Infrared Study of Supernova Ejecta and Dust

Principal Investigator: W. Peter Meikle
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Schuyler Van Dyk, Spitzer Science Center

Science Category: evolved stars/pn/sne
Observing Modes: IracMap IrsStare
Hours Approved: 35.1

Abstract:
We propose to use IRAC and IRS to gain powerful new insights on the nature of supernova (SN) explosions and test the hypothesis that SNe are major sources of cosmic dust. One of our two aims is to carry out robust tests of SN explosion models through the measurement of fine-structure (FS) lines and, where possible, their evolution. The important molecule, SiO, will also be measured. By comparison with our spectral synthesis models, we shall test the explosion model-sensitive predictions of abundances and their distribution. Most of the FS lines arise from ground state transitions and so, in comparison with optical or near-IR spectra, are much less sensitive to temperature and density uncertainties. However, the FS lines are only accessible in the MIR and the most useful abundance measurements can only be achieved at late times when the ejecta are optically thin. Consequently, ground-based MIR observations at the necessary late epochs are difficult if not impossible for nearly all SNe. Observation with the Spitzer Space Telescope is therefore essential. Our second goal is to test the proposal that core-collapse SNe (CCSNe) are, or have been, the major source of dust in the universe. Direct evidence in support of this is still very sparse. Warm dust emits most strongly in the MIR region, and so is the ideal wavelength range for following the condensation of dust within the ejecta or, in the case of Type IIn SNe, in a cool, dense shell formed at the ejecta/progenitor wind interface. Alternatively, such radiation may arise from IR light echo emission from dust in the progenitor wind. Discrimination between condensing dust and pre-existing circumstellar dust can be achieved by measurement of its MIR spectral energy distribution and evolution. Such measurements can also provide dust mass estimates and give clues about the nature of the grain material. To achieve our two goals, we propose to use IRAC and IRS to observe up to 17 SNe at epochs ranging from about 100 days to 2 years post-explosion.

Spitzer Space Telescope - General Observer Proposal #40010

SEEDS: The Search for Evolution of Emission from Dust in Supernovae with HST and Spitzer

Principal Investigator: Margaret Meixner
Institution: STScI

Technical Contact: Margaret Meixner, STScI

Co-Investigators:
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Geoffrey C. Clayton, Louisiana State University
Barbara Ercolano, Harvard University
Joanna Fabbri, University College London
Tim M. Gledhill, University of Hertfordshire
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Martin J. Meyer, Space Telescope Science Institute
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Angela Karen Speck, University of Missouri - Columbia
Ben E. Sugerman, Goucher College
Alexander Tielens, NASA Ames Research Center
Douglas L. Welch, McMaster University
Roger Wesson, University College London
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Albert Zijlstra, University of Manchester

Science Category: evolved stars/pn/sne
Observing Modes: IracMap IrsStare IrsPeakupImage MipsPhot
Hours Approved: 16.1

Abstract:
The role that massive stars play in the dust content of the Universe is extremely uncertain. It has long beenhypothesized that dust can condense within the ejecta of supernovae (SNe), however there is a frustratingdiscrepancy between the amounts of dust found in the early Universe, or predicted by nucleation theory, and inferred from SN observations. Our SEEDS collaboration has been carefully revisiting the observational case for dust formation by core-collapse SNe, in order to quantify their role as dust contributors in the early Universe. As dust condenses in expanding SN ejecta, it will increase in optical depth, producing three simultaneously observable phenomena: (1) increasing optical extinction; (2) infrared (IR) excesses; and (3) asymmetric blue-shifted emission lines. Our SEEDS collaboration recently reported all three phenomena occuring in SN2003gd, demonstrating the success of our observing strategy, and permitting us to derive a dust mass of up to 0.02 solar masses created in the SN. To advance our understanding of the origin and evolution of the interstellar dust in galaxies, we propose to use HST's WFPC2 and NICMOS instruments plus Spitzer's photometric instruments to monitor ten recent core-collapse SNe for dust formation and, as a bonus, detect lightechoes that can affect the dust mass estimates. These space-borne observations will be supplemented by ground-based spectroscopic monitoring of their optical emission line profiles. These observations would continue our 2-year HST and Spitzer monitoring of this phenomena in order to address two key questions: Do all SNe produce dust? and How much dust do they produce? As all the SN are witin 15 Mpc, each SN stands an excellent chance of detection with HST and Spitzer and of resolving potential light echoes.

Spitzer Space Telescope - General Observer Proposal #30598

Spectroscopy of the Unique Circumstellar Environment of U Equulei

Principal Investigator: Mark Morris
Institution: UCLA

Technical Contact: Mark Morris, UCLA

Co-Investigators:
Tom Geballe, Gemini Observatory
Keith Noll, STScI
Cecilia Barnbaum, Valdosta State Univ.

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 0.8

Abstract:
The oxygen-rich red giant U Equulei (IRAS 20547+0247) is one of the most mysterious evolved stars known. It is partially enshrouded by a thick, dusty envelope, but the nature of that envelope is like no other mass-loss envelope in our current inventory. We propose spectroscopic observations with the IRS high-resolution spectrometers over their full range to complement our existing 1-4 micron spectroscopy in order to better understand the physical conditions and the geometry of the circumstellar material and to help enlighten us regarding the events that created the envelope as we currently view it.

Spitzer Space Telescope - General Observer Proposal #3668

The Progression of Mass-Loss During the AGB Star?Planetary Nebula Transition

Principal Investigator: Mark Morris
Institution: UCLA

Technical Contact: Mark Morris, UCLA

Co-Investigators:
Raghvendra Sahai, JPL
Karl Stapelfeldt, JPL
Ken Young, Center for Astrophysics

Science Category: evolved stars/pn/sne
Observing Modes: MipsPhot
Hours Approved: 13.4

Abstract:
Mass loss on the asymptotic giant branch is a short-lived (few x 10^5 years) process that dramatically transforms low and intermediate-mass stars into white dwarfs, producing planetary nebulae during the transition. Evidence from molecular line observations, from optical studies of ionized gas, and from previous far-infrared studies from space collectively tends to indicate that the mass-loss process is unsteady, sometimes leading to one or more outflowing shells of matter, separated by distances that correspond to time scales of a few tens of thousands of years. However, because of the spherical divergence of the outflowing matter, it has been difficult to follow it in individual objects out to large enough radial distances that a large portion of the mass-loss history can be traced. We propose a pilot program with the MIPS imager on Spitzer to observe the extended dusty envelopes of six stars out to angular distances as large as 10 - 20 arcminutes, typically more than a parsec. At the usual speeds of AGB winds, ~15 km/s, such angular scales correspond to envelope expansion times approaching 10^5 years. Taking advantage of the sensitivity of MIPS to the faint outer emission from these outflows, we will be able to characterize the time variation in mass loss rate for this group of stars better than has previously been possible in any star. Once the time scales and the regularity, or lack thereof, of the shell ejection process have been established, these results can be used to constrain models for thermal pulsing in AGB stars, including how the interpulse period and pulse duration vary with the diminution of the stellar mass caused by mass loss. Our results will also provide a view of the asymmetric magnetohydrodynamic interaction between the outflowing wind and the ambient interstellar medium for comparison with recent models.

Spitzer Space Telescope - General Observer Proposal #3266

IRS Spectroscopy of Shocked Molecular Gas in Supernova Remnants: Probing the Interaction of a Supernova with a Molecular Cloud

Principal Investigator: David Neufeld
Institution: The Johns Hopkins University

Technical Contact: David Neufeld, The Johns Hopkins University

Co-Investigators:
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Michael Kaufman, San Jose State University
David Hollenbach, NASA Ames Research Center
Gary Melnick, Smithsonian Astrophysical Obsevatory
Ronald Snell, University of Massachusetts

Science Category: evolved stars/pn/sne
Observing Modes: IrsMap
Hours Approved: 17.2

Abstract:
We propose to carry out Spitzer/IRS observations of the interaction of a supernova with a molecular cloud. Using the Short-Lo, Short-Hi, and Long-Hi modes of IRS, we will perform spectral-line mapping over the entire IRS bandpass (5.3 - 37 micron) of a roughly 1 x 1 arcmin region in each of four supernova remnants: IC443 (clump C), 3C391, W28, and W44. The proposed observations will yield maps of the S(0) - S(7) pure rotational emissions from molecular hydrogen, several rotational emissions from water vapor, and fine structure emissions from FeI, FeII, SI, and SiII. Because the target transitions are either completely inaccessible from the ground and/or to weak to be mapped by warm telescopes, only Spitzer can perform the required observations. We will thereby compare the spatial distribution of warm molecular hydrogen and water vapor behind slow, non-dissociative molecular shocks with that of ionized iron and silicon behind faster, dissociative shocks. These observations will be critical because they will (1) elucidate the spatial relationship between the dissociative and non-dissociative shocks; (2) constrain the shock parameters in the different shock components, thereby allowing the ram pressures in the various shock components to be compared; and (3) allow the post-shock water abundance to be determined more reliably than has been possible to date, revealing the extent of ice destruction within the non-dissociative shock. The Spitzer observations proposed here will provide a critical test of fundamental modifications that we have proposed to the standard theory of molecular shock waves - involving the irradiation of slow molecular shocks by the ultraviolet radiation emitted by nearby fast shocks - in order to explain the anomalously low water vapor abundances observed recently in IC443.

Spitzer Space Telescope - General Observer Proposal #3583

Time Variation Observations of Mid-Infrared Spectra of Mira Variables in NEP and LMC

Principal Investigator: Takashi Onaka
Institution: University of Tokyo

Technical Contact: Takashi Onaka, University of Tokyo

Co-Investigators:
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Issei Yamamura, Institute of Space and Astronautical Science, JAXA
Takashi Miyata, University of Tokyo
Yoko Okada, University of Tokyo
Itsuki Sakon, University of Tokyo

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 10.5

Abstract:
We propose to derive the optical properties of their circumstellar dust grains and dust formation process based on variability observations of mid-infrared (MIR) spectra of oxygen-rich Mira variables with the IRS SL and LL modules. Mass-loss of stars in the asymptotic-giant branch is an important process for the evolution of matter in the Galaxy. However, there are still large uncertainties in the optical properties of silicate grains and the dust formation process in their circumstellar envelopes. Based on variability observations with the ISO of MIR spectra of a Mira variable we were able to derive the dust optical properties and the inner dust shell temperature independently, which have clearly demonstrated the effectiveness of variability observations of MIR spectra. However, they also indicate that the variability and dust properties in Mira variables have diversity and it is quite important to apply the same method to other targets and extend the investigation. We selected 3 target stars in the north ecliptic polar (NEP) region and 2 in the Large Magellanic Cloud (LMC). Both regions are located in the constant viewing zones and all the target stars can be observed for more than 11 months in a year. We propose to make observations in the intervals of 1/5 of the period over a variability cycle. Three targets in the NEP have periods less than 300 days and they can be observed over a variability cycle in Cycle-1. Two target stars in the LMC have periods longer than 500 days and we request multi-cycle observations to cover a variability cycle of the LMC targets. We allow +/-15 days for the NEP stars and +/-30 days for the LMC stars for each observation epoch and thus the timing constraint is not severe. The IRS on board the SST provides a unique opportunity to carry out this study, which enables us to investigate the diversity of properties and formation process of silicate grains in Mira variables and extend our understanding to those in the nearby galaxy LMC.

Spitzer Space Telescope - General Observer Proposal #30292

Infrared Study of Supernova Dust and Ejecta

Principal Investigator: W. Peter Meikle
Institution: Imperial College London

Technical Contact: W. Peter Meikle, Imperial College London

Co-Investigators:
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Ryan Foley, U. California at Berkeley
Claes Fransson, University of Stockholm
Christopher Gerardy, Imperial College London
Peter Hoeflich, University of Texas
Rubina Kotak, European Southern Observatory
Cecilia Kozma, University of Stockholm
Leon Lucy, Imperial College London
Peter Lundqvist, University of Stockholm
Seppo Mattila, Queen's University Belfast
Monica Pozzo, Imperial College London
Jesper Sollerman, University of Copenhagen
Craig Wheeler, University of Texas

Science Category: evolved stars/pn/sne
Observing Modes: IracMap IrsPeakupImage IrsStare
Hours Approved: 47.5

Abstract:
We propose to continue our Spitzer study of supernovae (SNe). Our first goal is to investigate core-collapse supernovae (CCSNe) as the major source of dust in the universe, past or present. Direct evidence in support of this is still very sparse. Warm grains emit most strongly in the mid-IR and so is the ideal wavelength range for following dust condensation in the ejecta or possibly in a cool, dense shell at the ejecta/progenitor wind interface. Alternatively, such radiation may arise from IR light echo emission from progenitor-wind dust. Discrimination between condensing dust and pre-existing circumstellar dust can be deduced from the mid-IR spectral energy distribution and evolution. Our Spitzer data have already provided evidence of dust IR emission in several CCSNe. In one case (SN 2002hh), an IR-echo seems to dominate. In Cycle 3, we propose to continue our monitoring program of some exceptionally nearby CCSNe during the phase (550 to 1000 days) when ejecta dust condensation is expected to peak. Our second goal is to test explosion models for all SN types by measuring the intensity and, where possible, the evolution of late-epoch fine-structure (FS) lines and molecular features. By comparison with our spectral synthesis models we shall test explosion-model-sensitive predictions of abundances. Most of the FS lines arise from ground state transitions and so, compared with optical/near-IR spectra, are much less sensitive to temperature and density uncertainties. However they are only accessible in the mid-IR and provide the most useful abundance measurements at late times when the ejecta are optically thin. Ground-based mid-IR observations at such late epochs are almost impossible. From data obtained in Cycles 1 & 2 we are building up a unique picture of the mid-IR behaviour of supernovae in the nebular phase. In Cycle 3 we shall enhance this study by monitoring the closest thermonuclear and core-collapse supernovae that have occurred since the launch of Spitzer.

Spitzer Space Telescope - Directors Discretionary Time Proposal #285

IRS spectroscopy of SN 2006gy - the most luminous known supernova

Principal Investigator: Arne Rau
Institution: Caltech

Technical Contact: Arne Rau, Caltech

Co-Investigators:
Shri Kulkarni, Caltech
Avishay Gal-Yam, Caltech
Patrick Cameron, Caltech

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 2.0

Abstract:
SN 2006gy is the brightest supernovae known to mankind. Its classification and progenitor model remains a mystery as both type-Ia and type-II like properties were observed. Here we propose IRS observations with SL2, SL1 and LL2 in order to study the properties of the ejected envelope of this enigmatic event. Specifically, we will attempt to measure the amount of stable Nickel, thus constraining the progenitor mass. Furthermore, the proposed observations will allow to directly obtain the chemical composition using fine structure lines and to study the onset of dust condensation.

Spitzer Space Telescope - General Observer Proposal #20752

Thermal and Nonthermal Emission from the Crab's Twin SNR B0540-693

Principal Investigator: Stephen Reynolds
Institution: North Carolina State U.

Technical Contact: Stephen Reynolds, North Carolina State U.

Co-Investigators:
Kazimierz Borkowski, NC State U
Brian Williams, NC State U
William Blair, Johns Hopkins
Parviz Ghavamian, Johns Hopkins
Ravi Sankrit, Johns Hopkins
Knox Long, STScI
Sean Hendrick, Drew U.
John Raymond, CfA
Chris Smith, NOAO
Sean Points, NOAO
Jon Morse, Arizona State U.
Frank Winkler, Middlebury

Science Category: evolved stars/pn/sne
Observing Modes: IrsMap IrsStare
Hours Approved: 4.1

Abstract:
We propose a deep spectroscopic investigation of the pulsar-driven supernova remnant B0540-693 in the LMC, known as the "Crab's Twin." This remnant contains a fast pulsar and synchrotron nebula, and a surrounding shell of thermal gas, probably the innermost ejecta. Optical spectra show velocities of order 2000 km/s and indicate an age of order 800 yr. We plan to obtain the broadband continuum shape, which should include the critical region in which spectral steepening between radio and optical must occur, with important implications for modeling pulsar-wind nebulae (PWNe). If hot dust is present, we may be able to detect it. We also plan echelle spectroscopy to obtain fluxes, and velocity profiles, of fine-structure lines of Si, S, Ar, Fe, and perhaps other elements, from which we hope to extract abundances more reliably than can be done with only optical spectra. We expect to determine whether material is shock-heated or photoionized, and will be able to test the prediction of a Type Ib/Ic origin for 0540. Velocity information should allow us to test the extent of velocity stratification and mixing. This object is the only O-rich SNR in which we observe innermost, rather than outer ejecta; with the PWN, it is a unique object and should amply repay careful study with Spitzer.

Spitzer Space Telescope - General Observer Proposal #50638

Spectral Mapping of Kepler's Supernova Remnant

Principal Investigator: Stephen Reynolds
Institution: North Carolina State U.

Technical Contact: Stephen Reynolds, North Carolina State U.

Co-Investigators:
Kazimierz Borkowski, North Carolina State University
William Blair, Johns Hopkins
Parviz Ghavamian, Johns Hopkins
Ravi Sankrit, SSL, UC Berkeley
Brian Williams, North Carolina State University
Knox Long, STScI

Science Category: evolved stars/pn/sne
Observing Modes: IrsMap
Hours Approved: 11.6

Abstract:
We propose to leverage our extensive previous multi-wavelength investigations of Kepler's supernova remnant (SN 1604) by obtaining IRS spectral maps of this premier example of a "massive Type Ia" remnant. Of particular interest is the dense circumstellar medium (CSM) evidently surrounding Kepler. This material is best investigated in infrared, where shock-heated dust reveals the thermal-gas density and possible composition clues such as the 10-micron silicate feature. Full LL coverage (14-38 um) will permit detailed mapping of continuum shape changes with spatial position that are only hinted at from our previous MIPS 24 and 70 um imaging. SL mapping of selected regions will permit detailed studies of changes in the silicate feature with position, suggested by two slit positions in earlier observations. Combined with our deep Chandra observation (750 ks), these data will permit a detailed study of dust destruction in fast shocks. Kepler also shows regions near the remnant edge dominated by synchrotron X-ray emission, indicating electron acceleration to energies of order 100 TeV. However, the dominance of synchrotron continuum means that properties of the thermal medium, important for understanding shock-acceleration physics, cannot be diagnosed with X-rays. Our IRS spectra should allow such diagnosis. Kepler's unique position among Type Ia supernova remnants makes it a critical target for the understanding of the Type Ia phenomenon.

Spitzer Space Telescope - General Observer Proposal #3483

Dust Formation and Heavy Elements in Young Supernova Remnants

Principal Investigator: Jeonghee Rho
Institution: Caltech

Technical Contact: Jeonghee Rho, Caltech

Co-Investigators:
Loretta Dunne, Nottingham University
William Reach, Caltech
Lawrance Rudnick, University of Minnesota
Tracey Delaney, University of Minnesota
Una Hwang, NASA/GSFC
Haley Morgan, Cardiff University
Jonathan Keohane, Caltech

Science Category: evolved stars/pn/sne
Observing Modes: IracMap IrsMap IrsStare MipsPhot
Hours Approved: 11.2

Abstract:
Young supernova remnants (YSNRs) are the most viable astrophysical laboratories for dust formation, and studies of these sources may explain the presence of huge quantities of dust observed in the early Universe. We propose to use IRAC, MIPS and IRS to observe a sample of six YSNRs: our sample includes sources located in a range of different interstellar environments and produced by both Type Ia and II supernovae. The goals of the proposed research include (i) searching for dust formed in the ejecta of YSNRs and measuring dust injection rates for different types of SNe, (ii) revealing dust structure through imaging at high angular resolution to help probe the onset and physical conditions of dust formation in YSNRs, (iii) using spectroscopy to probe dust composition and search for the missing Fe mass (as predicted to exist by nucleosynthesis models), and (iv) to study relativistic particle acceleration by YSNRs.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #77

Stellar Ejecta: Macro-Molecule and Dust Formation and Evolution

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: Kate Su, The University of Arizona

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare MipsPhot MipsScan MipsSed
Hours Approved: 31.9

Abstract:
Mass ejected into the interstellar medium during the early and late stages of stellar evolution -- protostellar jets, asymptotic giant branch (AGB) stellar mass loss, novae, and supernovae -- is the primary source of chemically enriched material to the interstellar medium (e.g. Jura 1987, in ISP). Dust and large "macro" molecules (polycyclic aromatic hydrocarbons or PAHs) are a major constituent of the interstellar medium, and strongly influence the physics and chemistry of the ISM. The origin and evolution of these key components are not well known. With IRAC we will determine the detailed structure in various tracers, such as the warm dust component and PAHs, molecular hydrogen (v=0-0), and various ionized species. The IRAC bands are well placed to be able to detect large scale emission in the IR PAH bands. Some confusion with other species will be present, but IRS spectroscopy will quickly resolve any issues. Its large field of view allows rapid study of some of the most well known, but poorly observed objects. MIPS will give us access to extended shells and ISM interactions, the cold and very cold components, interaction interfaces, with efficient wide field mapping and fast/accurate photometry with a wide FOV. MIPS SED mode will provide information on the temperature and composition of the cold and very cold components and the dust. IRS will be used for detailed composition and temperature studies of the dust, PAHs, and numerous atomic and molecular species available in the IRS wavelength ranges of the high and low resolution modules.

Spitzer Space Telescope - General Observer Proposal #30153

Cas A: before and after the shocks

Principal Investigator: Lawrence Rudnick
Institution: Univ. of Minnesota

Technical Contact: Lawrence Rudnick, Univ. of Minnesota

Co-Investigators:
Tracey DeLaney, Center for Astrophysics
Jessica Ennis, University of Minnesota
Haley (Morgan) Gomez, Cardiff University
Takashi Kozasa, Hokkaido University
William Reach, Spitzer Science Center
Jeonghee Rho, Spitzer Science Center
JD Smith, University of Arizona

Science Category: evolved stars/pn/sne
Observing Modes: IracMap IrsMap IrsStare
Hours Approved: 14.0

Abstract:
A remarkable picture of Cassiopeia A's explosion has been uncovered through multiwavelength studies over the latest 10% of its life, identifying its dual shock structure, its large scale asymmetries in ejection velocity and apparent composition, and the differential deceleration of optical, X-ray and radio emitting material in their encounters with the reverse shock. Our G01 discoveries have opened up yet another major window into the structure of the explosion, which is critical not only for the explosion physics, but also for nucleosynthetic yields, dust production, and the connection of supernovae with exotic objects such as gamma-ray bursters. This proposal seeks carefully selected IRAC, low and high resolution IRS mapping of key regions of Cas A to exploit these new findings. In particular, we will: a) determine the kinematics and physical properties of the newly found, slow-moving interior ejecta, from the central disk to where they pass through the reverse shock and slowly become ionized and heated; b) make the first measurements of dust proper motions, with implications for the survivability of dust in the harsh SNR environment; c) distinguish between intrinsic explosion asymmetries and external effects on the distribution of nucleosynthetic layers; d) explore the filamentary line network (wind?, ejecta?) outside of Cas A's forward shock; and e) provide a powerful additional probe of light echoes.

Spitzer Space Telescope - General Observer Proposal #3310

The Evolution of Dust in Cassiopeia A

Principal Investigator: Lawrence Rudnick
Institution: Univ. of Minnesota

Technical Contact: William Reach, Caltech

Co-Investigators:
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Loretta Dunne, Univ. of Nottingham
Stephen Eales, Cardiff University
Takashi Kozasa, Hokkaido University
Haley Morgan, Cardiff University
William Reach, Spitzer Space Center
Jeonghee Rho, Spitzer Space Center
JD Smith, Univ. of Arizona

Science Category: evolved stars/pn/sne
Observing Modes: IracMap IrsMap IrsStare
Hours Approved: 14.2

Abstract:
The supernova remnant Cas A is forming and destroying dust as it rapidly evolves on both large and small scales. The forward shock is sweeping up a clumpy CSM and its reverse shock is being overtaken by freely expanding ejecta, which are then shocked, heated and decelerated. These processes lead to multiple interacting 10^4K, 10^7K and relativistic plasmas which provide both the material and the environment in which the dust evolves. Multiple-epoch Chandra, HST and the VLA data, up to 2003-4, map out the current state and kinematics of these plasmas. With individual features brightening and fading over 30-50 years, we will sample structures in all possible dynamical states, allowing us to obtain a snapshot history of dust evolution. The addition of IRAC high resolution maps at 8 microns and global IRS mapping, as proposed here, along with the existing MIPS data and our sub-mm images, will thus allow us to construct a coherent picture of the evolution of dust and gas, with its large scale variations in composition, temperature and pre-SN mixing of ejecta layers. We will also make a critical measurement of the synchrotron brightness at 3.6, 4.5 micron to probe the likely important contribution of cosmic rays to the entire dynamical evolution of the remnant. The IRAC images and IRS data cube will serve as a public archive for comparison, e.g., with the coeval 1 Msec Chandra data and for future studies. The proposal team brings together people who are both leaders in the science of SNR and dust evolution and who have technical expertise in Spitzer instrumentation, multiwavelength observations, image and spectral analysis, theoretical modeling and who have genially evolved, for many years, along with Cas A.

Spitzer Space Telescope - General Observer Proposal #20590

Searching for the Missing Mass in Very Young Preplanetary Nebulae

Principal Investigator: Raghvendra Sahai
Institution: JPL

Technical Contact: Raghvendra Sahai, JPL

Co-Investigators:
Carmen Sanchez Contreras, Caltech
Mark Claussen, NRAO/AOC, Socorro
Mark Morris, UCLA

Science Category: evolved stars/pn/sne
Observing Modes: IracMap IrsStare MipsPhot MipsSed
Hours Approved: 8.0

Abstract:
Pre-Planetary nebulae (PPNe), objects in transition between the AGB and planetary nebula (PN) evolutionary phases, hold the key to our understanding of the late evolutionary stages of low and intermediate mass stars. Essentially all well-characterized PPNe are bipolar, whereas the mass-loss envelopes of AGB stars are strikingly spherical -- we find that almost all the targets observed in our HST surveys of young PPNe (yPPNe) which are resolved, show well-defined bipolar or multipolar morphologies. We have hypothesized that it is the hydrodynamic interaction of fast, tenuous collimated flows with the dense, cool massive envelope ejected during the AGB phase, which is responsible for shaping these objects. The bulk of the nebular mass in this envelope, is however not seen in the HST data, since much of it resides in a cool, dusty, molecular component surrounding the central aspherical nebula. Thus a crucial ingredient for theoretical studies of such interactions is lacking for a majority of the yPPNe discovered in our HST surveys. We propose to use IRAC, IRS & MIPS to characterise the infrared spectrum of a selected sample (16) of such objects from short to long wavelengths, as a primary probe of the total circumstellar mass. Detailed spectra and full SEDs are necessary in order to derive the total dust mass, which depends sensitively on the radial temperature distribution and can only be determined accurately by modeling the full infrared spectrum of these objects. Our spectra should also show specific dust features (e.g. silicate feature in absorption) which act as probes of different structural components (e.g. a central equatorial disk) and unusual physical processes (e.g. growth of icy grain mantles) in these objects, and constrain uncertainties in the dust properties (emissivity law, composition), which also affect the mass determination.

Spitzer Space Telescope - General Observer Proposal #2345

Mass Loss from Galactic Bulge Giants: Probing Stellar and Galactic Evolution

Principal Investigator: Raghvendra Sahai
Institution: JPL

Technical Contact: Raghvendra Sahai, JPL

Co-Investigators:
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Science Category: evolved stars/pn/sne
Observing Modes: IracMap MipsPhot
Hours Approved: 14.4

Abstract:
The Galactic Bulge (GB), an important dynamical and morphological component of our Galaxy, offers an environment distinct from the Galactic disk, for the study of stellar populations, stellar evolution and the mass-loss processes which accompany and in the end, control the latter. Understanding and calibrating the physical processes whereby mass ejected by evolved stars into the Bulge environment is recycled back into new generations of stars requires a statistical knowledge of mass-loss as a function of fundamental stellar parameters in this region. Because of the limited sensitivity of previous surveys of the Bulge, fundamental questions for late stellar evolution such as the stage at which substantial mass-loss begins on the RGB, and its dependence on fundamental stellar properties, remain unanswered. The GB is an ideal laboratory for addressing these issues, providing a very large sample of stars at a fixed distance (8.7 kpc). We therefore propose to observe seven 15 x 15 sq. arcmin fields in and around the vicinity of the nuclear bulge with unprecedented sensitivity using MIPS and IRAC, in order to measure mass-loss rates and luminosities of a statistically large sample of stars at several Galactocentric radii in the Bulge. With these data, we will (1) detect stars with mass-loss rates a factor 50 lower than the lowest detected previously, and thus determine whether mass-loss rate is already prevalent on the RGB, (2) determine the functional dependence of the mass-loss rate on luminosity (L) and effective temperature (T) for low values of L and T, (3) determine the evolution of mass-loss rate as stars evolve up the RGB and then to the AGB, and (4) determine the census of mass-losing stars at different rates. The proposed observations, together with existing studies which probe higher mass-loss rate stars, will enable us to infer the total rate of mass loss in the bulge, a key input to evolutionary models of the bulge.

Spitzer Space Telescope - General Observer Proposal #30788

Fundamental Properties of Pre-Planetary Nebulae: Observations in the Large Magellanic Cloud

Principal Investigator: Raghvendra Sahai
Institution: JPL

Technical Contact: Raghvendra Sahai, JPL

Co-Investigators:
Mark Claussen, AOC/NRAO
Matthias Stute, JPL
Mark Morris, UCLA

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 9.9

Abstract:
We propose to use Spitzer/IRS to observe 35 pre-planetary nebulae (PPN, objects in transition between AGB stars and planetary nebulae) in the LMC. PPNs hold the key to our understanding of the late evolutionary stages of low and intermediate mass stars. As they die, these stars return dust and gas to the interstellar medium, thus providing new material for the birth of new stars and solar systems. These proposed Spitzer observations will address fundamental questions about PPN such as their lifetimes, luminosities, nebular masses, and mass-loss rates. The answers to these questions will provide important constraints on theories of the evolution of PPNs into planetary nebulae, which will bear on the dust and gas return. The answers to such questions cannot be definitively answered by studying galactic PPNs, since the distances to galactic objects are, in general, very poorly known. Observations of PPNs in the LMC will allow us to unambiguously address these issues, since the distance to the LMC is well-known and distances to individual targets in the LMC is a minor perturbation. Spitzer/IRS is the instrument of choice for measuring the SEDs in the mid-infrared and dust absorption features because of its high sensitivity for short integration times. We can observe all 35 targets with high signal-to-noise ratios in 9.9 hours of telescope time.

Spitzer Space Telescope - General Observer Proposal #20743

Observations of the Cygnus Loop supernova remnant: dust processing in radiative and non-radiative shocks

Principal Investigator: Ravi Sankrit
Institution: The Johns Hopkins University

Technical Contact: Ravi Sankrit, The Johns Hopkins University

Co-Investigators:
William Blair, The Johns Hopkins University
John Raymond, CfA
Kazimierz Borkowski, NCSU
Parviz Ghavamian, The Johns Hopkins University
Terrance Gaetz, CfA
Knox Long, STScI

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare MipsPhot
Hours Approved: 11.3

Abstract:
We propose to address the important question of dust destruction in supernova remnant shocks by obtaining Spitzer IRS spectra and MIPS images of non-radiative and radiative shocks in the Cygnus Loop. Spectra will be obtained at various distances from a fast non-radiative shock front that is defined by a Balmer filament termed ‘P7’. The spectra will trace the evolution of the 5-35 micron continuum in the post-shock flow. This is the spectral region strongly affected by stochastic heating and destruction by sputtering of small grains. In the bright, radiative shock interaction region known as ‘XA’, spectra will be obtained at locations known to be at different stages of recombination. The IRS spectral range includes several emission lines that are abundance diagnostics. We will study the release of refractory elements into the gas phase as grains are sputtered and destroyed by comparing key flux ratios at the different locations. MIPS images will reveal the infrared morphologies of both P7 and XA regions at unprecedented spatial resolution. By comparing these images with X-ray and optical images we will be able to clarify the relationship among the different emitting components.

Spitzer Space Telescope - General Observer Proposal #50179

Planetary Nebulae As A Laboratory For Molecular Hydrogen in the Early Universe

Principal Investigator: Kris Sellgren
Institution: Ohio State University

Technical Contact: Kris Sellgren, Ohio State University

Co-Investigators:
Harriet Dinerstein, Univ. Texas, Austin
Volker Bromm, Univ. Texas, Austin

Science Category: evolved stars/pn/sne
Observing Modes: IrsMap
Hours Approved: 28.2

Abstract:
We propose to obtain Spitzer IRS observations of the mid-infrared rotational lines of H2 in planetary nebulae (PNe) with very hot central stars, T > 100,000 K. Our primary motivation is to investigate the excitation and cooling of H2 exposed to UV radiation near very hot stars, which can serve as a proxy for conditions in the early universe. Cosmological simulations show that the first stellar generation (Pop. III) had high masses, > 100 Msun, and hot photospheres. The UV radiation they produced and its effect on the thermal state of the ambient H2 is relevant to subsequent star formation because stellar masses are determined by accretion processes which depend on temperature, and the metal-free primordial gas cooled primarily through excited H2. Yet the effects of this radiative feedback are uncertain: for example, whether it triggers or suppresses further star formation, and the resultant characteristic masses of second generation stars, which are key to cosmic reionization. PNe with hot central stars may be the only place where we can study the relevant microphysics. We therefore propose to obtain Spitzer spectra of such nebulae, sampling regions with a range of gas densities and radiation field dilution factors. We will use the results to derive an improved H2 cooling function to be incorporated into state of the art cosmological models. Our targets have been previously observed in the near-infrared H2 lines, so we have confidence that the lower excitation rotational lines are detectable. Evidence already exists that in some PNe the excited rotational states are overpopulated relative to standard fluorescence models, and that this may be related to the presence of Lyman-continuum photons. The observations proposed here will enable us to verify and quantify this phenomenon, and improve our understanding of H2 excitation. Spitzer is the only facility at present - and for at least the next decade - which can accomplish these goals.

Spitzer Space Telescope - General Observer Proposal #3647

Breaking Down the Spectra of Pulsar Wind Nebulae

Principal Investigator: Patrick Slane
Institution: Smithsonian Astrophysical Observatory

Technical Contact: Patrick Slane, Smithsonian Astrophysical Observatory

Co-Investigators:
David Helfand, Columbia University
Stephen Reynolds, North Carolina State University
Bryan Gaensler, Harvard University

Science Category: evolved stars/pn/sne
Observing Modes: IracMap MipsPhot
Hours Approved: 14.5

Abstract:
We propose Spitzer observations of a selected set of pulsar wind nebulae. Using relatively modest MIPS exposures, we will probe the spectral region in which critical information resides regarding spectral breaks that must occur between the radio and X-ray bands. The frequency at which such breaks occur, as well as the magnitude of the change in spectral index, provides information on the spectrum injected by the pulsar, subsequent particle acceleration, and the evolution of the PWNe. By considering PWNe in different phases of evolution - from pure ‘‘Crab-like’’ nebulae to those situated within the confines of supernova remnant (SNR) shells - we will place constraints on the underlying cause of the spectral features in these nebulae. We will also obtain important information regarding emission from dust that may reside in ejecta filamants and material swept up by the SNR blast wave.

Spitzer Space Telescope - General Observer Proposal #40736

IRS Spectroscopy of the Shell Surrounding the Pulsar Wind Nebula

Principal Investigator: Patrick Slane
Institution: Smithsonian Astrophysical Observatory

Technical Contact: Patrick Slane, Smithsonian Astrophysical Observatory

Co-Investigators:
Stephen Reynolds, North Carolina State University
Bryan Gaensler, University of Sydney
John Raymond, Smithsonian Astrophysical Observatory
Tea Temim, University of Minnesota

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 3.1

Abstract:
G54.1+0.3 is a young pulsar wind nebula for which Spitzer observations reveal a bright shell into which the nebula is expanding. The IR emission may arise from shocked supernova ejecta being swept up by the expanding nebula, or from dust being shocked and/or irradiated by the nebula. The brightest region in the shell is spatially coincident with the termination of an outflow structure seen in X-ray observations of the nebula. We propose IRS spectra of the shell with which we will identify or constrain the abundances of the ejecta, the temperature and ionization state of the gas, the amount of dust produced in the ejecta, and the nature of the bright emission near the pulsar jet.

Spitzer Space Telescope - General Observer Proposal #50279

Probing the Spectral Breaks in 3C 58

Principal Investigator: Patrick Slane
Institution: Smithsonian Astrophysical Observatory

Technical Contact: Patrick Slane, Harvard-SAO

Co-Investigators:
David Helfand, Columbia University
Stephen Reynolds, North Carolina State University
Bryan Gaensler, University of Sydney
Tea Temim, Smithsonian Astrophysical Observatory

Science Category: evolved stars/pn/sne
Observing Modes: MipsPhot
Hours Approved: 8.0

Abstract:
Spitzer observations of pulsar wind nebulae probe a unique spectral region which provides information on the spectrum injected by the pulsar, subsequent particle acceleration, and the evolution of the PWNe. In Spitzer AO-1 we carried out IRAC observations of 3C 58, a PWN powered by a powerful young pulsar. Our observations reveal the first detection of synchrotron emission from this nebula outside the radio and X-ray bands, and provide strong evidence for a spectral break between these bands. More importantly, we have discovered IR emission from the pulsar torus, and the associated broadband spectral behavior appears to indicate deviations from a single power law in the injection spectrum. If correct, this has considerable consequences for our interpretation of the pulsar injection spectrum and the age, evolution, and magnetic field structure. Here we propose MIPS observations of 3C 58 at 24 and 70 microns in order to obtain higher fidelity spectral information in this crucial break region.

Spitzer Space Telescope - General Observer Proposal #50447

IRS Spectroscopy of Kes 75: Constraints on the Properties of Dust in Supernova Remnants

Principal Investigator: Patrick Slane
Institution: Smithsonian Astrophysical Observatory

Technical Contact: Patrick Slane, Harvard-SAO

Co-Investigators:
Tea Temim, Smithsonian Astrophysical Observatory
Timothy Morton, Caltech
Stephen Reynolds, NC State
Bryan Gaensler, Sydney University

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 0.8

Abstract:
Recent modeling of Chandra and Spitzer data from the supernova remnant Kes 75 reveals shock-heated circumstellar and ejecta material in X-rays along with infrared emission that constrains the amount of dust in the ambient material. Our results show a dust-to-gas mass ratio that is much smaller than values typically assumed for the Milky Way. This is consistent with similar results from studies of LMC remnants, although the cause of this apparent dust depletion is not currently understood. Our constraints for Kes 75 are limited by our very imprecise knowledge of the dust spectrum. Here we propose short IRS observations to obtain spectra from the limbs of Kes 75 in order to derive the dust emission properties and determine the total dust mass. Our observations will also be sensitive to faint line emission that may be produced by the shocked SNR gas, potentially providing measurements of the thermodynamic state of the IR-emitting gas, and constraining the abundance of Fe in the ejecta.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40111

The mass loss and dust composition of evolved stars in globular clusters

Principal Investigator: Gregory Sloan
Institution: Cornell University

Technical Contact: Gregory Sloan, Cornell University

Co-Investigators:
Mikako Matsuura, National Astron. Obs. of Japan
Noriyuki Matsunaga, Univ. of Tokyo
A.A. Zijlstra, Manchester Univ.
K.E. Kraemer, Air Force Research Lab.
Jeronimo Bernard-Salas, Cornell Univ.
Daniel Devost, Cornell Univ.

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 18.8

Abstract:
We propose to observe 39 mass-losing evolved stars in 22 globular clusters with the IRS on the Spitzer Space Telescope. All of the stars in our sample should have similar ages and initial masses. This full sample will allow us to compare oxygen-rich dust spectra from stars spanning the metallicity range 0.0 < [Fe/H] < -2.0. Subsamples will give us a good range of periods of variability for a variety of metallicities, including six sources in Terzan 5 ([Fe/H] = 0.00) and four sources in NGC 6356 ([Fe/H] = -0.50). These observations will help us understand how oxygen-rich dust forms in stellar outflows, how the composition depends on metallicity, and how the metallicity, mass-loss rate, dust formation, and evolution on the asymptotic giant branch (AGB) are interrelated. This IRS GTO proposal requests 18.8 hours of IRS time.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #40112

Infrared spectroscopy of naked M giants

Principal Investigator: Gregory Sloan
Institution: Cornell University

Technical Contact: Gregory Sloan, Cornell University

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 5.2

Abstract:
We propose to observe a sample of 20 naked M giants from M0 III to M6 III in order to quantify the dependence of silicon monoxide equivalent width and infrared continuum shape on spectral class. Having a sample of three sources at each spectral class will probe the intrinsic spread of these parameters within each spectral class. These observations will improve our understanding of how the strength and shape of the SiO band at 8 um, varies with photospheric temperature. We will also search for differences between the assumed and observed continuum shape out to 38 um. These observations will also provide a pool of spectra which will reduce errors in the assumed spectra used to isolate the spectral contribution from circumstellar shells and disks. This IRS GTO proposal requests 5.2 hours of IRS time.

Spitzer Space Telescope - General Observer Proposal #20258

MIPS Infrared Imaging of AGB Dustshells (MIRIAD): tracing mass-loss histories in the extremely large shells around evolved stars

Principal Investigator: Angela Speck
Institution: University of Missouri - Columbia

Technical Contact: Angela Speck, University of Missouri - Columbia

Co-Investigators:
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Hideyuki Izumiura, Okayama Astrophysical Observatory, National Astron
Robert Stencel, University of Denver
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Ryszard Szczerba, Nicolaus Copernicus Astronomical Center, Poland
Moshe Elitzur, University of Kentucky
Robert Gehrz, University of Minnesota
William Latter, Spitzer Science Center, Caltech
Mikako Matsuura, University of Manchester, UK.
Matthias Steffen, Astrophysikalisches Institut Potsdam, Germany
Albert Zijlstra, University of Manchester, UK.
Margaret Meixner, STScI

Science Category: evolved stars/pn/sne
Observing Modes: MipsPhot
Hours Approved: 30.0

Abstract:
Evolved intermediate mass stars are major contributors to the interstellar medium. However, the mechanisms by which they do this are not well understood. The circumstellar shells of evolved stars (AGB and post-AGB stars) contain the fossil record of their mass loss, and therefore have the potential to verify many aspects of stellar evolution. IRAS and ISO data indicate that huge dust shells exist around many such objects, extending several parsecs from the central star. Furthermore, these large dust shells show evidence for mass-loss variations that correlate with evolutionary changes in the star itself. Previous observations lacked the sensitivity and spatial resolution to investigate the full extent and detailed structure of these large dust shells. Using Spitzer/MIPS's unique sensitivity and mapping capabilities, we propose to produce far-IR images of the parsec-sized dust shells around four carefully selected evolved stars in order to determine the distribution of material in these circumstellar envelopes. These maps will be the deepest yet (sensitivity 1MJy/sr) and have the most complete spatial coverage to date. Crucially, mapping in this level of detail will allow us to: (a) constrain the masses of the progenitor stars; (b) test theories of stellar evolution and mass-loss mechanisms; (c) determine the effect of dust chemistry on mass loss (and therefore on stellar evolution); (d) determine when the aspherical structures so prevalent in planetary nebulae actually develop and thus constrain the cause.

Spitzer Space Telescope - General Observer Proposal #50261

Dust, gas, and metallicity in compact Galactic disk planetary nebulae: the missing evolutionary link

Principal Investigator: Letizia Stanghellini
Institution: National Optical Astronomical Observatory

Technical Contact: Letizia Stanghellini, NOAO

Co-Investigators:
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Anibal Garcia-Hernandez, IAC
Richard Shaw, NOAO
Eva Villaver, STScI
Arturo Manchado, IAC
Jose Vicente Perea-Calderon, ESA

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 31.8

Abstract:
Planetary nebulae (PNe) are ideal probes of dust formation and evolution in low- and intermediate- mass stars. The analysis of dust emission in the 5 to 40 micron range, however, has concentrated mainly on a relatively small number of nearby Galactic PNe. The analysis has been recently extended to fainter sources located in the direction of the Galactic Bulge, and in the Galactic Halo. In addition, a significant number of Magellanic Cloud PNe was also studied by us with Spitzer/IRS. This has allowed us to study the dust properties and derive preliminary conclusions which suggest that indeed there are strong differences in the characteristics of the dust observed from source to source which seem to be mainly dependent on the mass of the progenitor star and the metallicity. To complete the picture, we propose to study with Spitzer/IRS the mid-IR spectra of all Galactic Disk PNe smaller than 4 arcsec (excluding duplications) to reveal the relations between nebular dust, gas abundance, and metallicity, at early evolutionary stages, as most compact PN are expected to be dynamically young. With the proposed observations we will solve some key questions on the formation and evolution of dust in PNe, such as the dependency of mass-loss with metallicity and progenitor mass. The statistical properties inferred from the proposed observations will be analyzed relatively to those of Magellanic Clouds, Galactic Halo and Galactic Bulge PNe, to asses the main characteristics of the particular solid state features detected in C-rich and O-rich PN as a function of the stellar population, with a large metallicity baseline. In addition, the proposed observations will yield alpha-element abundances with lower uncertainties than previosuly calculated. The Galactic distribution of our targets are such that metallicity gradients will also be derived from this program. The large and complete sample will fill a gap in the Spitzer program, with a strong legacy value.

Spitzer Space Telescope - General Observer Proposal #20358

Pinning down the composition of the extraordinary planetary nebula PNG 135.9+55.9

Principal Investigator: Grazyna Stasinska
Institution: Observatoire de Paris-Meudon

Technical Contact: Grazyna Stasinska, Observatoire de Paris-Meudon

Co-Investigators:
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Ralf Napiwotzki, Dept. of Physics and Astronomy, University of Leic
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Miriam Pena, Inst. de Astronomia, UNAM
Corinne Charbonnel, Geneva Observatory

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 3.4

Abstract:
PN G 135.9+55.9 is an extraodinary planetary nebula discovered recently in the Galactic halo . Its oxygen abundance lies between 1/125 and 1/25 of the solar value (i.e. it is by far the most oxygen-poor planetary nebula known). Its nucleus is a spectroscopic binary, with a period of a few hours at most (the only such case known among planetaruies). Our analysis of the binary orbit indicates that the companion is a massive compact object, most likely a white dwarf, making the central star a double degenerate. Since the minimum combined mass is close to the Chandrasekhar limit, it is a very good candidate SN Ia progenitor. Determining accurately the chemical composition of PN G 135.9+55.9 is paramount not only to test models of stellar evolution and nucleosynthesis at very low metallicity but also to constrain the poorly understood common envelope phase preceeding the formation of the double degenerate. We propose to use the SST to obtain accurate values of the O/H and Ne/O ratio, (which in turn will constrain the N/O and C/O ratios that can be derived from available STIS HST observations) and to obtain an estimate of the S/H and, possibly, Ar/H ratios.

Spitzer Space Telescope - Directors Discretionary Time Proposal #236

Observing Iron Stars with Spitzer

Principal Investigator: Beth Thomas
Institution: East Middle School

Technical Contact: Steve Howell, National Optical Astronomical Observatory

Co-Investigators:
Lauren Chapple, Traverse City East Junior High School
Steve Rapp, Linwood Holton Governor's School
Theresa Roelofson, Bassick High School
Cindy Weehler, Luther Burbank High School
Doris Daou, Spitzer Science Center

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 0.5

Abstract:
Only two so-called Iron stars exist: XX Oph and AS 325. XX Oph was first observed in 1924 by Merrill. He noted strong, doubly ionized iron emission lines were present in the spectra, thus the name iron star. AS325 was noted to be a similar type object by Howell and Bopp (1982). Further observations of both stars have led to the development of a model (Cool et al., 2005) for both stars which explains the optical emission lines and that the stars consist of two separate stars, possibly in a binary. The current model has each Iron Star composed of a Be star and a late type (supergiant) companion separated by 1-2 thousand AU. We plan to use Spitzer to observethe dust environment in the star AS325.

Spitzer Space Telescope - General Observer Proposal #40092

Excavating the Mass Loss History in the Circumstellar Dust Shells of Evolved Stars (Spitzer-MLHES)

Principal Investigator: Toshiya Ueta
Institution: University of Denver

Technical Contact: Toshiya Ueta, University of Denver

Co-Investigators:
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Angela Speck, University of Missouri - Columbia
Hideyuki Izumiura, Okayama Astronomical Observatory, Japan

Science Category: evolved stars/pn/sne
Observing Modes: MipsPhot
Hours Approved: 25.0

Abstract:
Using Spitzer/MIPS's unique observing capabilities, we propose to observe the spatial distribution of the far-IR emission from extended circumstellar dust shells (CDSs) of 37 asymptotic giant branch (AGB) stars. Our sample is volume-limited (< 500 pc) and includes all known extended AGB CDSs whose internal structures can be resolved by Spitzer at 70 microns. We will determine the dust distribution in these shells and thus, (a) directly characterize AGB mass loss variations in the CDSs; (b) confront our observational data with a range of theoretical predictions to determine the effect of dust chemistry on mass loss and the cause of the aspherical CDS structures; and (c) constrain the masses of the progenitor stars. Most importantly, we will achieve our science goals by deriving statistically sound conclusions using a complete structure-resolvable sample in the solar neighborhood. The mechanisms by which these evolved stars lose their mass to the surrounding space are not well understood. The AGB CDSs contain the fossil record of their mass loss, and therefore have the potential to verify many aspects of stellar evolution. IRAS and ISO data indicate that extended AGB CDSs exist showing evidence for mass-loss variations that correlate with evolutionary changes in the star itself. However, previous observations lacked both quantity (data are scarce) and quality (sensitivity and spatial resolution) to investigate the full extent and detailed structure of these large CDSs in statistically meaningful ways. Hence, it is more than timely to apply the powerful capabilities of Spitzer/MIPS to study the far-IR structure and evolution of these extended CDSs at moderately high resolution and sensitivity, for which there are presently no superior alternatives to Spitzer. The AGB CDSs are being detected at a high rate (> 60%) in an on-going AKARI-MLHES study at lower resolution and sensitivity: the likelihood for success of this proposed Spitzer-MLHES program at higher resolution and sensitivity is therefore enhanced.

Spitzer Space Telescope - Directors Discretionary Time Proposal #226

Spitzer Observations of a Nearby Supernova (SONS): SN 2004dj in NGC 2403

Principal Investigator: Schuyler Van Dyk
Institution: Spitzer Science Center

Technical Contact: Schuyler Van Dyk, Spitzer Science Center

Co-Investigators:
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Robert Fesen, Dartmouth College
Rubina Kotak, Imperial College London
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Peter Meikle, Imperial College London

Science Category: evolved stars/pn/sne
Observing Modes: IracMap IrsStare MipsPhot
Hours Approved: 5.8

Abstract:
The discovery of a new, nearby (3.1 Mpc) supernova, 2004dj, in the nearly face-on spiral galaxy NGC 2403 offers an unprecedented opportunity for the community to investigate in detail in the mid-infrared the brightest core-collapse supernova that will likely occur during Spitzer's lifetime. A multi-instrument campaign is proposed on behalf of the entire astronomical community as a Director's Discretionary Time program. Prior to Spitzer there were extremely little data available for supernovae in the mid-infrared, other than for SN 1987A in the LMC. These observations should shed valuable light on the explosion models for supernovae and for the contribution by supernovae to dust production in the Universe. The insight gleaned from the multi-epoch data obtained by Spitzer will be a lasting legacy to be exploited by the community for decades to come.

Spitzer Space Telescope - Directors Discretionary Time Proposal #237

Spitzer Observations of a Nearby Supernova: SN 2005af in NGC 4945

Principal Investigator: Schuyler Van Dyk
Institution: Spitzer Science Center

Technical Contact: W. Peter Meikle, Imperial College London

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 1.6

Abstract:
IRS observations of supernova 2005af.

Spitzer Space Telescope - General Observer Proposal #50603

The Unusual Supernova 1978K: A Supernova Remnant in Formation?

Principal Investigator: Schuyler Van Dyk
Institution: Spitzer Science Center

Technical Contact: Schuyler Van Dyk, Spitzer Science Center

Science Category: evolved stars/pn/sne
Observing Modes: IracMap IrsStare MipsPhot IrsPeakupImage
Hours Approved: 3.0

Abstract:
We know very little about the evolution of supernovae as they age and evolve to supernova remnants. We also cannot yet explain why galaxies at high redshift, early in the history of the Universe, show appreciable dust content so early on. Various models have introduced the possibility that core-collapse supernovae from early stars may be the main contributors of the dust. Recently, particularly with Spitzer, several investigations have attempted to determine whether or not supernovae, based on nearby events, produce enough dust to match the model predictions. So far, the results have not been promising, but the supernovae have been from relatively low-mass progenitors. Analysis of the dust content in the young Galactic supernova remnant Cas A, which may have had a very massive Wolf-Rayet star progenitor, has indicated that possibly enough dust has been freshly formed to be in agreement with the lower limits of these models. This indicates potentially that supernovae from high-mass stars could be adequate dust producers. The unusual supernova 1978K has very recently been imaged in IRAC and MIPS observations of its host galaxy, NGC 1313. From data at other wavelengths it appears that this supernova is now evolving to the remnant phase. Many indicators point to this supernova having had a very massive stellar progenitor---it therefore could have been producing large amounts of dust in the ejecta. The supernova is very luminous in the mid-infrared, as seen by Spitzer, nearly 30 years after explosion, and we are proposing to obtain an IRS spectrum, as well as follow-up IRAC, MIPS, and PUI imaging, to investigate more fully the state of its evolution and the nature of the dust emission from the object.

Spitzer Space Telescope - General Observer Proposal #3274

Dusty discs around binary post-AGB stars and their relation to protoplanetary discs.

Principal Investigator: Hans Van Winckel
Institution: Instituut voor Sterrenkunde, K.U.Leuven

Technical Contact: Hans Van Winckel, Instituut voor Sterrenkunde

Co-Investigators:
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Tom Lloyd Evans, St. Andrews, Scotland, UK
Stephanie De Ruyter, UGent, Belgium
Thomas Maas, K.U.Leuven
Alex de Koter, Anton Pannekoek, Amsterdam

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 7.7

Abstract:
We propose to obtain IRS spectra in the SH and LH mode of a sample of carefully selected binary post-AGB stars. Through detailed observing campaigns, we have recently established that these binaries are surrounded by a Keplerian dusty disc. The ISO-SWS spectra of only the few brightest examples, have shown that concerning mass, kinematics, mineralogy and dust processing, the circumstellar environment around the evolved stars resemble very much the protoplanetary discs around young stellar objects. They are therefore a unique laboratory to study the gas physics and dust mineralogy of Keplerian discs on quite different evolutionary timescales and radiation fields than during the star formation process. The detailed structure, let alone the formation, stability and evolution of the circumbinary discs around evolved stars are not well understood. With the new sample of IRS spectra, and our detailed modeling with state-of-the art radiative transfer codes based on modern laboratory data, we aim at a better understanding of the rich chemistry and strong processing of the different gas and dust components. Our carefully selected sample covers a significant range in orbital periods and understanding the properties of such Keplerian discs around binaries, will provide also insight in the role of binarity in the shapes and shaping of (proto) Planetary Nebulae.

Spitzer Space Telescope - General Observer Proposal #3235

The composition and evolution of circumstellar dust from AGB to post-AGB and PNe phases.

Principal Investigator: Christoffel Waelkens
Institution: Institute for Astronomy

Technical Contact: Christoffel Waelkens, Institute for Astronomy

Co-Investigators:
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Rens Waters, University of Amsterdam, The Netherlands
Sacha Hony, ESTEC/SCI-SA, The Netherlands
Hans Van Winckel, Institute for Astronomy, K.U.Leuven, Belgium

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 7.5

Abstract:
Mid-IR spectroscopy has revealed systematic differences in the dust compounds present around AGB, post-AGB objects and PNe. This has been interpreted as evidence for a rapid evolution of circumstellar dust when low mass stars transit from the AGB to the post-AGB and PNe phases. Moreover, few of these dust spectral signatures are present in the ISM, casting some doubt on the interrelationship of circumstellar and interstellar dust. However, these previous studies were limited to the brightest objects of these different classes and did not probe a homogeneous sample of stars in these phases. Here, we propose to obtain IRS spectra in SH, LH, and SL mode of highly evolved, low and intermediate mass stars. Particularly, we aim at observing oxygen and carbon-rich AGB stars at high galactic latitudes with high mass-loss rates, and high-mass oxygen-rich post-AGB stars in the galactic plane. Because of sensitivity, these types of objects were completely missed in previous studies. The dust sequence resulting from this study, will not only give us insight in the formation of dust and its processing due to the hardening of the radiation field during the stellar evolution, but will also provide us with a better census of the dust injected in the interstellar medium.

Spitzer Space Telescope - General Observer Proposal #2333

ToO Observations of Galactic and Magellanic Cloud Classical Novae

Principal Investigator: Charles Woodward
Institution: Univ. Minnesota

Technical Contact: Charles Woodward, Univ. Minnesota

Co-Investigators:
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James Truran, Univ. Chicago
Nye Evans, Keele Univ.
Thomas Geballe, Gemini Obs.
Peter Hauschildt, Univ. Hamburg
Joachim Krautter, Univ. Heidelberg
Richard Rudy, Aerospace Corp
William Liller, Univ. Chile
James Lyke, Keck Obs.
Greg Schwarz, Univ. Arizona
Mattew Greenhouse, NASA Goddard
Michael Bode, Liverpool John Moores Univ.
Michael Barlow, Univ. College London
Alberto Salama, ISO Vilspa
Steven Shore, Univ. of Pisa
Robert Williams, StSci
R. Mark Wagner, LBT Observatory
Michael Skrutskie, Univ. Virginia

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 10.5

Abstract:
Stars are the engines of energy production and chemical evolution in our Universe. They deposit radiative and mechanical energy into their environments, and enrich the ambient interstellar medium with elements synthesized in their interiors and dust grains condensed in their atmospheres. Classical novae (CN), a transient phenomenon, contribute to this cycle of chemical enrichment through explosive nucleosynthesis and the violent ejection of material dredged from the white dwarf progenitor and mixed with the accreted surface layers. Using Spitzer (+IRS), we propose a 10.5 hr, no-impact, multi-cycle (2) ToO program to study (in temporal detail) the later evolutionary stages of CN (> 40 days post-outburst) by targeting 4 Galactic and 3 Magellanic Cloud novae. Spitzer is a unique facility that can enable us to investigate aspects of CN phenomenon including: the in situ formation and astromineralogy of dust, the elemental abundances resulting from thermonuclear runaway, the correllation of ejecta masses with progenitor type, the bolometric luminosities of the outburst, and the kinematics and structure of the ejected envelopes. Specifically, our program addresses four research problems in the study of CN evolution: 1)~determination of the grain size distribution and mineral composition of nova dust; 2)~estimation of chemical abundances of nova ejecta from coronal and forbidden emission line spectroscopy; 3)~measurement of the density and masses of the ejecta; and 4)~characterization of the nature of novae in the SMC and LMC at mid- to far-infrared wavelengths.

Spitzer Space Telescope - General Observer Proposal #30007

ToO IRS Observations of Novae

Principal Investigator: Charles Woodward
Institution: Univ. Minnesota

Technical Contact: Charles Woodward, Univ. Minnesota

Co-Investigators:
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Richard Rudy, Aerospace Corporation
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Joachim Krautter, Landessternwarte
William Liller, U. Chile
James Lyke, Keck Obs.
Steve Shore, U. Pisa
Alberto Salama, ESA/Vilspa
Jim Truran, U. Chicago
R. Mark Wagner, LBT Obs

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 25.8

Abstract:
Stars are the engines of energy production and chemical evolution in our Universe. They deposit radiative and mechanical energy into their environments and enrich the ambient interstellar medium with elements synthesized in their interiors and dust grains condensed in their atmospheres. Classical novae (CN) contribute to this cycle of chemical enrichment through explosive nucleosynthesis and the violent ejection of material dredged from the white dwarf progenitor and mixed with the accreted surface layers. Using Spitzer (+IRS), we propose a 25.8 hrs no-impact ToO program to study (in temporal detail) the evolutionary stages of CN by targeting 4 Galactic and 2 Magellanic Cloud (MC) novae. Spitzer is a unique facility that enables us to investigate aspects of the CN phenomenon including the in situ formation and astromineralogy of nova dust, the elemental abundances resulting from thermonuclear runaway, the correlation of ejecta masses with progenitor type, the bolometric luminosities of the outburst, and the kinematics and structure of the ejected envelopes. Synoptic, high signal-to-noise IRS spectra permit: 1) determination of the grain size distribution and mineral composition of nova dust; 2) estimation of chemical abundances of nova ejecta from coronal and other emission line spectroscopy; 3) measurement of the density and masses of the ejecta; 4) characterization of the geometry and structure of ejected shells at early stages during which the initial mixing of the chemical abundances can be studied in detail; and 5) exploration of the characteristics of CN in low metallicity systems (MC) at mid- to far-IR wavelengths. Observations of CN with Spitzer will be complemented by extensive ground-based, as well as space-based (e.g., Chandra, Swift, XMM-Newton), DDT and ToO programs led by team CoIs.

Spitzer Space Telescope - General Observer Proposal #50011

Dust, Abundances, and the Evolution of Novae

Principal Investigator: Charles Woodward
Institution: Univ. Minnesota

Technical Contact: Charles Woodward, Univ. Minnesota

Co-Investigators:
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Karen Vanlandingham, West Chester U. (Penn)
David Lynch, Aerospace Corporation
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Michael Bode, John Moores Liverpool Univ.
Thomas Geballe, Gemini Observatory
Robert Gehrz, University of Minnesota
Joachim Krautter, Landessternwarte
Steve Shore, Universita de Pisa
James Truran, University of Chicago
R. Mark Wagner, LBT Observatory

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare MipsPhot
Hours Approved: 34.1

Abstract:
Evolved stars are the engines of energy production and chemical evolution in our Universe. They deposit radiative and mechanical energy into their environments. They enrich the ambient ISM with elements synthesized in their interiors and dust grains condensed in their atmospheres. Classical novae (CNe) contribute to this cycle of chemical enrichment through explosive nucleosynthesis and the violent ejection of material dredged from the white dwarf progenitor and mixed with the accreted surface layers. Our capstone study of 10 CNe will provide an ensemble of objects, well-populated in CNe parameter space (fast, slow, 'coronal', dusty) for detailed photoionization modeling and analysis. CNe are laboratories in which several poorly-understood astrophysical processes (e.g., mass transfer, thermonuclear runaway, optically thick winds, common envelope evolution, molecule and grain formation, coronal emission) may be observed. With Spitzer's unique wavelength coverage and point-source sensitivity we can: (i) investigate the in situ formation, astromineralogy, and processing of nova dust, (ii) determine the ejecta elemental abundances resulting from thermonuclear runaway, (iii) constrain the correlation of ejecta mass with progenitor type, (iv) measure the bolometric luminosity of the outburst, and (v) characterize the kinematics and structure of the ejected envelopes. Extensive ground-based and space-based (Chandra, Swift, XMM-Newton) programs led by team CoIs will complement Spitzer CNe observations.

Spitzer Space Telescope - General Observer Proposal #50458

Dust production in omega Centauri

Principal Investigator: Jacco van Loon
Institution: Keele University

Technical Contact: Jacco van Loon, Keele University

Co-Investigators:
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Martha Boyer, University of Minnesota
Charles Woodward, University of Minnesota
Aneurin Evans, Keele University
Andrea Dupree, Harvard-Smithsonian Center for Astrophysics
Robert Gehrz, University of Minnesota

Science Category: evolved stars/pn/sne
Observing Modes: IrsStare
Hours Approved: 15.9

Abstract:
Mass loss is a crucial factor in stellar evolution, in galactic chemical evolution and in the dynamical evolution of star clusters. Mass loss from red giant stars also makes a significant contribution to the production of dust in the Universe. There is however no theory that can predict the mass loss and dust production from these stars, and that can be extrapolated to the low metallicity environment of the early Universe. With the goal of determining the evolution of mass loss and dust production on the red giant branches in a metal-poor environment, we have conducted an infrared imaging survey with IRAC and MIPS of the most massive galactic globular cluster, the nearby (5 kpc) omega Centauri (GO-2 program 20648; Boyer et al. 2007). The spectacular images reveal dozens of stars with circumstellar dust. Using the proper motion survey of van Leeuwen et al. (2001) and our own, extensive optical spectroscopic survey (van Loon et al. 2007) we are able to confidently separate cluster members from foreground stars and background galaxies. We now propose to obtain spectra in the full low-resolution IRS range of 15 cluster members that are in their final stages of evolution including, uniquely, post-AGB and carbon stars. These data will allow us to accurately measure the dust masses, to chart the mineralogical evolution of the dust from the onset of dust production to the post-mass loss phase, and to determine any dependencies on the chemical composition of the stellar photosphere. This is only possible with the Spitzer Space Telescope, and will leave a lasting legacy for the interpretation of many other Spitzer programmes whilst taking important steps towards a theory for red giant mass loss and dust production.

Spitzer Space Telescope - General Observer Proposal #3394

The formation of clusters: Comparing the star formation processes in the Rosette and Maddalena Clouds

Principal Investigator: Ian Bonnell
Institution: University of St Andrews

Technical Contact: Ian Bonnell, University of St Andrews

Co-Investigators:
Jane Greaves, University of St Andrews

Science Category: star clusters
Observing Modes: IracMap MipsScan
Hours Approved: 9.1

Abstract:
We propose to map the regions of the massive cores in the Rosette and Maddalena molecular clouds. These two regions demonstrate similar properties except that one has ongoing star formation and the other is as yet inactive. The principle aim of this proposal is to investigate the physical conditions (morphologies, mass distributions) that are necessary for the formation of stellar clusters. Local conditions must play a role, as even in the Rosette half of the cores contain embedded clusters while the others, of similar masses do not. We are primarily interested in establishing if there is an evolutionary process within massive cores that leads to the necessary physical conditions for cluster formation. We also want to investigate what role the external environment plays in triggering the formation of stellar clusters. This will be accomplished by establishing the structure of the core on large (several pc) and small (<0.1 pc) scales and by relating any large-scale structure to the possible external triggering sources. This work will be extremely useful in testing and developing theories of the onset of star formation and the origin of stellar clusters

Spitzer Space Telescope - General Observer Proposal #20438

Mass Loss From Stars in Globular Clusters

Principal Investigator: Joel Bregman
Institution: Univerisity of Michigan

Technical Contact: Joel Bregman, Univerisity of Michigan

Co-Investigators:
Mario Mateo, University of Michigan
Patrick Seitzer, University of Michigan

Science Category: star clusters
Observing Modes: IrsMap
Hours Approved: 9.7

Abstract:
Evolved stars reveal the presence of mass-loss through their excess 10um emission, which comes from silicate grains that are heated in slow stellar winds. This has been a lively research area for nearby field giants, but with Spitzer, mass loss finally can be studied in globular clusters, systems with well-defined ages and metallicities. We propose to measure the strength of the silicate emission as a function of metallicity and age for selected globular clusters in the Milky Way and the LMC. These measurements will yield the cluster-wide stellar mass loss rates, a critical test of stellar evolutionary models. Of equal importance, these observations will enable us to age-date early-type galaxies, breaking the age-metallicity degeneracy that plagues the other main method.

Spitzer Space Telescope - General Observer Proposal #20772

Measuring Stellar Oscillations Using Spitzer: P-Modes in the Hyades

Principal Investigator: Derek Buzasi
Institution: US Air Force Academy

Technical Contact: Derek Buzasi, US Air Force Academy

Co-Investigators:
Heather Preston, US Air Force Academy

Science Category: star clusters
Observing Modes: IracMap
Hours Approved: 16.0

Abstract:
Observations of oscillations in solar-like stars are limited by the fact that the level of variability involved is typically very small (approximately 4-5 parts per million at optical wavelengths). While heroic efforts have made it possible to detect oscillations in a few solar-like stars from the ground, the most astrophysically interesting targets -- those in nearby open clusters -- are unreachable and likely to remain so for many years. Solar observations have shown that the amplitude of oscillations seen in the 4.7-micron CO lines is nearly two orders of magnitude higher than that seen at optical wavelengths. For solar-like stars, such lines dominate the spectrum in IRAC Band 2. In fact, we estimate that the amplitude of p-mode oscillations in that band will be approximately 200 parts per million. This is 40 times the level in the optical, and easily accessible using Spizer. We propose a long time series of observations of the star VB 64, in the Hyades. We anticipate being able to detect a number of distinct oscillation modes, and thus to determine the large separation. In combination with other, previously measured, physical parameters of VB 64, we expect to be able to determine values for mass, age, and chemical composition which are at least an order of magnitude more precise that has been previously possible for any star in the Hyades.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30031

Cold Dust in Globular Clusters

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Pauline Barmby, SAO

Co-Investigators:
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Martha Boyer, University of Minnesota
Robert Gehrz, University of Minnesota
Elisha Polomski, University of Minnesota
Charles Woodward, University of Minnesota
Jacco van Loon, University of Keele

Science Category: star clusters
Observing Modes: MipsPhot
Hours Approved: 6.2

Abstract:
We propose MIPS imaging observations to detect cold intracluster dust in Milky Way globular clusters. Intracluster dust is an expected result of mass loss during stellar evolution, and thus an important check on stellar evolution and population synthesis models. While warm dust has been detected around individual mass-losing stars in globular clusters, almost all previous searches for a cold intracluster medium have been unsuccessful. The MIPS sensitivity should allow detection of dust masses of 1e-5 solar masses, well below previous surveys' upper limits.

Spitzer Space Telescope - General Observer Proposal #30800

Exploring the Luminosity Function for Prototypical Open Clusters with IRAC

Principal Investigator: Peter Frinchaboy
Institution: University of Virginia

Technical Contact: Peter Frinchaboy, University of Wisconsin-Madison

Co-Investigators:
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Robert Mathieu, University of Wisconsin
Steven Majewski, University of Virginia

Science Category: star clusters
Observing Modes: IracMap
Hours Approved: 18.5

Abstract:
We propose to map WIYN open cluster survey (WOCS) clusters with all four IRAC bands. The WOCS sample is characterizing ‘‘prototypical’’ open clusters, which sample a range of ages and metallicities. A primary challenge to exploring such crowded , low latitude fields is the significant contamination of the clusters by field stars, which obscures the true size of the cluster and renders the color-magnitude diagram (CMD) almost uninterpretable. The combination of near-infrared (i.e., 2MASS) and Spitzer IRAC photometry allows a direct and powerful assessment of the line of sight reddening and extinction to each star in the cluster. We propose to use this dereddening technique by combining new deep NIR and IRAC photometry to provide an individual reddening and extinction (A_K) for each star. Because the stars in the cluster are at the same distance, they should suffer approximately the same degree of extinction and reddening, whereas contaminating stars at different distances will have a different A_K. We intend to use these "relative reddening parallaxes" to eliminate obvious cluster non-members and produce valuable, cleaned cluster CMDs as well as 2-D spatial distributions. These cleaned CMDs will provide the strongest observational constraints yet to the luminosity function, stellar evolution, and binary fractions for key open clusters that are commonly used as calibrators for extragalactic stellar population studies.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #132

IRAC and MIPS Images of Omega Cen

Principal Investigator: Robert Gehrz
Institution: University of Minnesota

Technical Contact: Elisha Polomski, University of Minnesota

Science Category: star clusters
Observing Modes: IracMap MipsPhot
Hours Approved: 3.7

Abstract:
We will obtain data to construct IR HR diagrams of a globular cluster including a long-wave search for dust.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30802

IRAC Mapping of IC 2391

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: Erick Young, The University of Arizona

Co-Investigators:
Erick Young, University of Arizona
James Muzerolle, University of Arizona
David Trilling, University of Arizona
Nick Sieigler, University of Arizona

Science Category: star clusters
Observing Modes: IracMap
Hours Approved: 3.2

Abstract:
We propose to map the central square degree of the cluster IC 2391 using IRAC. As one of the nearest (145 pc) young (50 Myr) clusters, IC 2391 is a key target for understanding the evolution of debris disks as well as studying the cluster IMF. The proposed IRAC map complements the MIPS map we obtained under the initial GTO program. These IRAC data are important in our analysis of the MIPS data by accurately allowing us to fix the photospheric levels for the later type stars. The IRAC maps will be sufficiently sensitive to detect the photospheres to well below the hydrogen burning limit. By using the IRAC data in conjunction with a large amount of existing ancillary data (2MASS, ground-based visual maps, spectroscopy) we will be able to clearly identify members of the cluster and produce a clean measurement of the IMF in a 50 Myr cluster.

Spitzer Space Telescope - General Observer Proposal #20298

Exploring the Unknown Physics of Mass Loss in First Ascent Population II Red Giants

Principal Investigator: Robert Rood
Institution: University of Virginia

Technical Contact: Robert Rood, University of Virginia

Co-Investigators:
R. Michael Rich, UCLA
Livia Origlia, Osservatorio Astronomico di Bologna
Francesco Ferraro, Universita di Bologna
Flavio Fusi Pecci, Osservatorio Astronomico di Bologna

Science Category: star clusters
Observing Modes: IracMap
Hours Approved: 26.0

Abstract:
The main goal of this proposal is to take a major step forward in the understanding of mass loss (ML) in first ascent Population II giants with varying stellar parameters and metal content. To do this we use globular clusters as metallicity-selected red giant reservoir. We propose deep IRAC imaging of the dense centers of 17 globular clusters, spanning the entire range of metallicity between approximately a hundredth solar up to solar. Our experience with similar observations made with ISOCAM (Origlia, et al. 2002) indicates that we will be able to detect warm circumstellar dust in the stellar winds of many red giants in the IRAC 5.8 and 8 micron bands. With the 3.6 and 4.5 micron bands and our near-IR database we can accurately account for any photospheric contribution and derive ML rates. The ISOCAM observations suggested that the ML occurs well below the red giant branch tip and that even near the tip many stars were undergoing ML at rates below the detection limit. To improve significantly upon the ISOCAM results requires that we go significantly deeper than any existing Spitzer observations of globular clusters. Special care has been devoted to the cluster selection. At a given metallicity we have chosen pairs of globular clusters which should have high and normal mass loss rates based on their horizontal branch (HB) morphology. The proposed observations will yield the first empirical mass loss formula calibrated over a large range of metallicity. It will also show whether observed mass loss in individual stars within a cluster correlates as expected with that cluster's HB morphology. How the observed mass loss rates correlate with stellar parameters--luminosity, atmospheric opacities, isotopic ratios, etc--will yield insight to the processes which drive the mass loss.

Spitzer Space Telescope - General Observer Proposal #20710

Fundamental Calibrations of Intermediate-Age Solar-Abundance Stars: IRAC Observations of the 2MASS Messier 67 Calibration Tile

Principal Investigator: Michael Skrutskie
Institution: University of Virginia

Technical Contact: Michael Skrutskie, University of Virginia

Co-Investigators:
Roc Cutri, Caltech/Infrared Processing and Analysis Center

Science Category: star clusters
Observing Modes: IracMap
Hours Approved: 3.4

Abstract:
We propose an IRAC observation to cover the 2MASS calibration field which includes the open cluster M67. 2MASS observed this field more than 3600 times producing a database of remarkable relative photometric accuracy permitting precise spectral classification on the basis of color alone. In the deep combination of all of these observations cluster members are detected to nearly the hydrogen burning limit. M67 is prototypical of a solar-age solar-metalicity population. Its mid-IR characterization is of value for both constraining stellar evolution as well as for population synthesis.

Spitzer Space Telescope - General Observer Proposal #20127

The Star Formation History (and Future) of RCW 38

Principal Investigator: Scott Wolk
Institution: Harvard Smithsonian Center for Astrophysics

Technical Contact: Scott Wolk, Harvard Smithsonian Center for Astrophysics

Co-Investigators:
S. Thomas Megeath, CfA
Tyler Bourke, CfA

Science Category: star clusters
Observing Modes: IracMap MipsPhot
Hours Approved: 9.6

Abstract:
The only cluster within 2 kpc of the Sun containing over 1000 stars, other than the ONC, is RCW 38 (Lada & Lada 2003). We propose to observe this nearby (1.7 kpc), very dense and deeply embedded star forming region with IRAC and MIPS. Our deep Chandra observation has detected point-like X-ray emission from a few hundred embedded stars and diffuse X-ray emission from a stellar wind driven by the central O5 star. Our radio and VLT data show a complex and compact core region with several hundred stars encased in warm dust several parsecs in extent. By combining our X-ray, near-IR and radio data with data from Spitzer we will (1) trace the full extent of the population, to understand the sequence of events and current activity within the region -- in particular we will investigate the timescale of disk clearing and the effect of the massive stars on the disks of the low mass stars; (2) examine the relationship among the ionizing plasma, the molecular gas, radio continuum emission and diffuse mid-infrared emission; and (3) investigate the population of deeply embedded hard X-ray sources in our Chandra observations not detected in the near-infrared, which may be a population of protostars.

Spitzer Space Telescope - General Observer Proposal #3547

Testing Stellar Populations Models with IRAC Observations of Intermediate-Age Globular Clusters in NGC~4365

Principal Investigator: Steve Zepf
Institution: Michigan State University

Technical Contact: Steve Zepf, Michigan State University

Co-Investigators:
Arunav Kundu, Michigan State University
Thomas Puzia, STScI
Markus Kissler-Patig, ESO
Maren Hempel, ESO

Science Category: star clusters
Observing Modes: IracMap
Hours Approved: 1.3

Abstract:
We propose to obtain IRAC images of the nearby elliptical galaxy NGC 4365 and its intermediate age globular cluster subsystem. The proposed Spitzer observation, along with extensive existing HST and ground-based data, will allow important tests of models of stellar populations with high metallicities and intermediate ages. This is a critical parameter space for interpreting observations of early-type galaxies at cosmological distances. NGC 4365 is a key testing ground for the behavior of simple stellar populations at high metallicities and intermediate ages because of its rich and well-defined population of globular clusters with ages of 3-5 Gyr and metallicities ranging from slightly subsolar to supersolar. The globular clusters of NGC 4365 have already been extensively studied with HST WFPC2, ACS, and NICMOS observations, as well as 8-10m ground-based spectroscopy and photometry. The proposed IRAC photometry extends this dataset to longer wavelengths and offers an efficient test whether models of simple stellar populations accurately reproduce observations in the IRAC bands for an important set of ages and metallicities.

Spitzer Space Telescope - General Observer Proposal #20648

An atlas of omega Centauri at mid-infrared wavelengths

Principal Investigator: Jacco van Loon
Institution: Keele University

Technical Contact: Jacco van Loon, Keele University

Co-Investigators:
Martha Boyer, University of Minnesota
Anne Dupree, Harvard-SAO
Aneurin Evans, Keele University
Robert Gehrz, University of Minnesota
Elisha Polomski, University of Minnesota
Charles Woodward, University of Minnesota

Science Category: star clusters
Observing Modes: IracMap MipsScan
Hours Approved: 18.4

Abstract:
The most massive galactic globular cluster, Omega Centauri serves as a template for stellar and galactic astrophysics. The unusually large observed spread in metal abundance, from [Fe/H]=-2 to -0.5, still awaits a satisfactory explanation - proposed scenarios include self-enrichment, cluster mergers and the dissolution of a dwarf spheroidal galaxy. The population spread can also be used to our advantage to probe the evolution of low-mass stars across a range in metallicity that is not easily accessible elsewhere but which holds vital clues to our understanding of the early, metal-poor Universe. We propose to map the Omega Cen cluster with IRAC and MIPS to detect the stellar photospheres of all red giants as faint as ~100 Lsun. The resulting atlas and photometric catalogue will provide the by far deepest and least biased mid-IR inventory of the content of any large stellar system. In particular, it will result in a complete census of dust-producing red giants on the first ascent (RGB) and asymptotic (AGB) branches. This enables us to determine the rates and timescales for red giant mass loss and their dependence on metal abundance, elucidating the nature of the RGB mass loss and the second parameter that (besides metallicity) determines the Horizontal Branch morphology in intermediate-metallicity systems. It is essentially unknown how mass loss proceeds at low metallicities of [Fe/H]<-1, where dust condensation and coupling with the gas is expected to become extremely feeble. Yet dusty red giants are found in metal-poor globular clusters such as M15 at [Fe/H]=-2.2. Omega Cen offers us a rare opportunity to directly trace the evolution of mass loss across a crucial but largely uncharted regime in metallicity. Our proposed survey of Omega Cen with Spitzer does precisely that. Understanding the mass-loss mechanism in metal-poor stars may ultimately allow us to reliably reconstruct the initial phases of chemical enrichment in the high-redshift Universe.

Spitzer Space Telescope - Legacy General Observer Proposal #20597

MIPSGAL : A 24 and 70 Micron Survey of the Inner Galactic Disk with MIPS

Principal Investigator: Sean Carey
Institution: SSC

Technical Contact: Sean Carey, SSC

Co-Investigators:
Alberto Noriega-Crespo, Spitzer Science Center
Stephan Price, Air Force Research Labortory
Deborah Padgett, Spitzer Science Center
Babar Ali, IPAC
Bruce Berriman, IPAC
Francois Boulanger, IAS-Universite Paris-Sud
Roc Cutri, IPAC
Remy Indebetouw, University of Virginia
Jim Ingalls, Spitzer Science Center
Thomas Kuchar, Boston College
Kathleen Kraemer, Air Force Research Laboratory
Bill Latter, IPAC
Francine Marleau, Spitzer Science Center
Don Mizuno, Boston College
Marc-Antoine Miville-Deschenes, CITA/University of Toronto
Sergio Molinari, Istituto Fisica Spazio Interplanetario-CNR
Luisa Rebull, Spitzer Science Center
Leonardo Testi, Arcetri Observatory

Science Category: galactic structure
Observing Modes: MipsScan
Hours Approved: 417.0

Abstract:
We propose a 220 square degree survey of the inner Galactic plane, 65 < l < 10 and -10 < l < -65 for abs(b) < 1, at 24 and 70 microns with MIPS. Our survey complements existing (GLIMPSE) and proposed (Hi-Gal) surveys of the Galactic plane and has signifcantly better resolution and sensitivity than previous infrared surveys covering plane. Over 75% of the survey area should have useful data at 70 microns, while >99% of the plane is expected to be unsaturated at 24 microns. The survey data will be used to examine the early phases of high mass star formation, complete the census of star formation in the inner Galactic disk and provide a snapshot of the current Galactic star formation rate, measure the distribution and heating of very small grains in the ISM and most importantly enable research by the astronomical community. To that end, we waive proprietary rights to the data and plan to make available enhanced data products including a high quality point source catalog, image mosaics and to faciliate the study of extended emission, large format and source subtracted mosaics.

Spitzer Space Telescope - Legacy General Observer Proposal #146

The SIRTF Galactic Plane Survey

Principal Investigator: Ed Churchwell
Institution: University of Wisconsin

Technical Contact: Christer Watson, Manchester College

Co-Investigators:
Thomas Bania, Boston University
Robert Benjamin, University of Wisconsin
Joseph Cassinelli, University of Wisconsin
Daniel Clemens, Boston University
John Dickey, University of Minnesota
James Jackson, Boston University
Henry Kobulnicky, University of Wisconsin
Alexander Lazarian, University of Wisconsin
John Mathis, University of Wisconsin
Sara Seager, Princeton Institute for Advanced Study
Barbara Whitney, Space Science Institute
Mike Wolff, Space Science Institute
Mark Wolfire, University of Maryland

Science Category: galactic structure
Observing Modes: IracMap
Hours Approved: 400.0

Abstract:
We propose to image the inner galaxy from 10 to 70 degrees on either side of the Galactic center and one degree above and below the plane (240 square degrees) in all IRAC and MIPS bands. The survey will be fully sampled in all bands except at 160 μm. It will reach the three natural sensitivity limits: the saturation limit at wavelengths 70 μm and longer; the background limit at 24 μm; and, the confusion limit in the IRAC bands. This survey will be as good as can be obtained with SIRTF or any other telescope regardless of the integration time or observing strategy. It will require less than 20% of the time set aside for SIRTF Legacy programs. This SIRTF survey will: 1) produce a complete census of star formation in the inner galaxy; 2) measure the stellar disk scale length; 3) delineate the stellar structure of the molecular ring, inner spiral arms and bar as traced by the distributions of stars and star formation regions; 4) determine the luminosity and initial mass functions of all nearby star formation regions and clusters down to the stellar limit; 5) detect all young O and B stars still embedded in their natal clouds; 6) detect and identify young stellar objects (surrounded by circumstellar disks) in nearby star forming regions; 7) determine the interstellar extinction law in dense regions for the first time; 8) investigate the nature of Photo Dissociation Regions and the density structure within the interstellar medium; and, 9) detect a host of other types of stars and nebulae such as supernovae, planetary nebulae, hidden galaxies, OH/IR stars, etc. that will be of interest to a large fraction of the community. An additional value of a large, unbiased Galactic plane survey is its potential for new discoveries that might otherwise be missed by piecemeal imaging of selected regions.

Spitzer Space Telescope - Directors Discretionary Time Proposal #195

The SIRTF Galactic Plane Survey (GLIMPSE) Validation Observations

Principal Investigator: Ed Churchwell
Institution: University of Wisconsin

Technical Contact: Christer Watson, Manchester College

Co-Investigators:
The GLIMPSE Team ,

Science Category: galactic structure
Observing Modes: IracMap
Hours Approved: 10.0

Abstract:
Validation observations of the Galactic Plane Survey (GLIMPSE).

Spitzer Space Telescope - Legacy General Observer Proposal #20201

GLIMPSE II: Imaging the Central +/-10 Degrees of the Galactic Plane with IRAC

Principal Investigator: Ed Churchwell
Institution: University of Wisconsin

Technical Contact: Ed Churchwell, University of Wisconsin

Co-Investigators:
Babler Brian, University of Wisconsin-Madison
Tom Bania, Boston University
Bob Benjamin, University of Wisconsin-Whitewater
Dan Clemens, Boston University
Martin Cohen, University of California-Berkeley
John Dickey, University of Tasmania
Gerry Gilmore, Cambridge University
Remy Indebetouw, University of Virginia
James Jackson, Boston University
Henry Kobulnicky, University of Wyoming
Cornelia Lang, University of Iowa
John Mathis, University of Wisconsin-Madison
Marilyn Meade, University of Wisconsin-Madison
Emily Mercer, Boston University
Susan Stolovy, Spitzer Science Center
Christer Watson, Manchester College
Barbara Whitney, Space Science Institute
Mike Wolff, Space Science Institute
Mark Wolfire, University of Maryland
Joris Blommaert, Katholieke Universiteit Leuven
Alain Omont, Institute d' Astrophysique de Paris
Frederic Schuller, Max Planck Institute fÃ¼r Radioastronomie
Mathias Schultheis, Observatoire de Bescancon

Science Category: galactic structure
Observing Modes: IracMap
Hours Approved: 148.8

Abstract:
The Galactic center region of our galaxy is unique with conditions not duplicated anywhere else in the Galaxy. Several large-scale features such as the central bar, a large stellar wind-blown bubble centered on the nucleus and perpendicular to the Galactic plane, and the nuclear bulge have been identified but their detailed properties such as size, axial ratios, orientation, mass, dynamics, etc. are poorly known. Even the distinction between the nuclear bulge and central bar has been questioned. Such poor understanding of fundamental features of our own Galaxy needs to be rectified. We propose here to provide a large sample of spectral energy distributions (SEDs from 1-8 microns) and positions of stellar tracers that will contribute to a better understanding of the large scale structures in the inner part of our Galaxy. We propose a fully sampled, unbiased, confusion-limited survey toward longitudes +/- 10 deg of the central region of the Galaxy in all 4 IRAC bands. The latitude coverage will be +/- 1 deg from abs(l)=10 deg to 5 deg, +/-1.5 deg from

Spitzer Space Telescope - General Observer Proposal #20245

Spitzer Observations of Magellanic Cloud Microlensing Events

Principal Investigator: Andrew Gould
Institution: The Ohio State University

Technical Contact: Andrew Gould, The Ohio State University

Co-Investigators:
Andrew Boden, Michelson Science Center/Caltech
William Reach, Spitzer Science Center/Caltech
Andrzej Udalski, Warsaw University Observatory
David Bennett, University of Notre Dame
Giovanni Fazio, Harvard-Smithsonian Center for Astrophysics
Kim Griest, University of California, San Diego

Science Category: galactic structure
Observing Modes: IracMap
Hours Approved: 19.8

Abstract:
The outstanding question in the interpretation of microlensing events observed toward the Magellanic Clouds (MC) is the location and nature of the lens population. Because Earth-based photometric observations are ambiguous in inferring the lens distance, existing MC survey events can be explained by lenses in the Galactic halo, the Galactic disk, the clouds themselves, or a combination of all three. Here we propose an exploratory program of target-of-opportunity Spitzer/IRAC photometric observations of LMC microlensing events detected in an ongoing ground-based survey. Because of Spitzer's Earth-trailing orbit, combining Spitzer and ground-based photometry determines the lens ‘‘microlens parallax’’, which unambiguously distinguishes among the three possible populations. A handful of such determinations will unambiguously settle the lens location controversy and associated uncertainty in interpreting MC microlensing surveys, and allow the determination of whether the putative halo lenses comprise a significant component of Galactic dark matter.

Spitzer Space Telescope - Directors Discretionary Time Proposal #253

Added Observation of Ongoing Microlensing Event

Principal Investigator: Andrew Gould
Institution: The Ohio State University

Technical Contact: William Reach, Caltech

Co-Investigators:
Andy Boden, Caltech
Giovanni Fazio, Harvard-Smithsonian
Kim Griest, UCSD
William Reach, SSC
Andrzej Udalski, Warsaw University Observatory

Science Category: galactic structure
Observing Modes: IracMap
Hours Approved: 1.5

Abstract:
We request 1.5 hours of Director's Discretionary Time for an additional observation of the Target of Opportunity OGLE-2005-SMC-001. To obtain reasonable S/N with Spitzer, the source of the microlensing event had to be a red giant (or possibly a subgiant). Such MC microlensing events are quite rare. However, the event turned out to be even more unusual than we originally expected, and these unusual characteristics open up the possibility of increasing the precision of our result well beyond our original expectations, with a very modest exposure time. The event is quite long, and appears it will reach high magnification. By making this observation near peak we can break the "discrete degeneracy" that impacts the interpretation of microlensing events.

Spitzer Space Telescope - General Observer Proposal #3127

24 Micron Survey of the Galactic Plane

Principal Investigator: James Jackson
Institution: Boston University, Institute for Astrophysical Res

Technical Contact: James Jackson, Boston University

Co-Investigators:
Nye Evans, University of Keele
Henry Matthews, Herzberg Institute of Astrophysics
Jill Rathborne, Boston University, Institute for Astrophysical Res
Ronak Shah, Boston University, Institute for Astrophysical Res
Robert Simon, University of Cologne
Bernd Weferling, James Clerk Maxwell Telescope

Science Category: galactic structure
Observing Modes: MipsScan
Hours Approved: 13.3

Abstract:
We propose a pilot survey at 24micron of the Galactic plane. Our survey will cover 5 deg^2 centered on l=44deg and b=0deg. This region includes cold quiescent clouds, active star--forming regions and interarm material. A 24micron survey is a timely and critical source of information for separating warmer dust identified in the mid--IR from cooler dust observed in mm and sub-mm images. The pilot region complements existing and planned imaging from 1mm to IRAC/GLIMPSE imaging. We will estimate the integrated dust properties as a function of environment, and apply standard techniques to investigate the distribution of point sources and extended emission in the data. A key aspect of this project will be obtaining distances toward discrete 24micron sources using the GRS. The combination of a MIPS 24micron survey, GRS, as well as GLIMPSE IRAC and MSX images, will offer unique insights into the physical nature of star formation.

Spitzer Space Telescope - General Observer Proposal #20499

Galactic Structure Through the Dusty Veil

Principal Investigator: Steven Majewski
Institution: University of Virginia

Technical Contact: Steven Majewski, University of Virginia

Co-Investigators:
Michael Skrutskie, University of Virginia
Remy Indebetouw, University of Virginia
Helio Rocha-Pinto, Observatorio do Valongo, Brazil
Richard Patterson, University of Virginia

Science Category: galactic structure
Observing Modes: IracMap
Hours Approved: 68.9

Abstract:
As the only galaxy for which we can obtain detailed information on the chemical, kinematical, and spatial distribution of large numbers of individual stars, the Milky Way (MW) is a primary laboratory for understanding the structure and evolution of spiral galaxies. However, we are denied clear views of stellar populations at low Galactic latitudes because of dust extinction. With Spitzer IRAC + 2MASS photometry we now have a powerful method to determine the line of sight reddening to any star, due to the fact that the longer bands in this combination sample the Rayleigh-Jeans part of the spectral energy distribution of stars, where all stars have essentially the same color. Thus, changes in NIR + mid-IR colors from reddening become immediately obvious and accurately measurable. We will use this technique to ‘‘restore’’ previously uninterpretable 2MASS color-magnitude diagrams (CMD) of fields along the Galactic plane and allow the first field star CMD studies of the MW in these regions. The Spitzer-targeted fields have been selected to address several perenniel and newly recognized problems in MW structure. We will: 1) Explore the recently discovered ‘‘ring’’ that appears to wrap around our disk in the 2nd and 3rd quadrants. 2) Test the claim of a new dwarf galaxy situated near this ring in Canis Major. 3) Probe a ‘‘core’’ overdensity of the ring -- perhaps the center of a dwarf galaxy creating the ring as a tidal tail -- hidden behind the dust. 4) Explore for the density, metallicity and kinematical distributions of stars in the MW disk to its edge. We will find the radius and shape of the disk and measure the rotation of the outer disk. 5) Check the Schlegel reddening maps across a wide range of dust conditions, and determine the three dimensional dust distribution for our survey regions. This study of IRAC+2MASS photometry through the veil of Galactic dust represents a major step forward in Galactic structure studies. These ‘‘textbook’’ measurements will be a true legacy from Spitzer.

Spitzer Space Telescope - General Observer Proposal #40791

Galactic Structure and Star Formation in Vela-Carina

Principal Investigator: Steven Majewski
Institution: University of Virginia

Technical Contact: Steven Majewski, University of Virginia

Co-Investigators:
Michael Skrutskie, University of Virginia
Remy Indebetouw, University of Virginia
Helio Rocha-Pinto, Observatorio do Valongo, Brazil
Richard Patterson, University of Virginia
Christer Watson, Manchester College
Marilyn Meade, University of Wisconsin
Brian Babler, University of Wisconsin
Edward Churchwell, Univserity of Wisconsin-Madison
David Nidever, University of Virginia

Science Category: galactic structure
Observing Modes: IracMap
Hours Approved: 119.3

Abstract:
GLIMPSE and GLIMPSE2 have surveyed a large fraction of the Milky Way's star formation, as evidenced by the IRAS distribution of Galactic 25um flux, but at least two significant regions of star formation lie beyond the GLIMPSE survey area. Omission of these regions from GLIMPSE leaves a critical gap in the Spitzer legacy in the area of star formation in the outer, lower metallicity disk. Here we propose to extend GLIMPSE-style coverage to galactic longitudes 255 < l < 295 to cover 86 square degrees of the Carina and Vela regions of the Galactic plane. In addition to largely completing the characterization of mid-plane Galactic star formation by extending GLIMPSE to regions at and beyond the Solar circle, this 120-hour IRAC survey will probe the stellar distribution in the Sagittarius and Perseus arms and beyond. Using a technique we have developed to ascertain reddening estimates to individual stars from combined Spitzer and 2MASS photometry and to produce reliable color-magnitude diagrams and photometric parallax distances of useful stellar population tracers, we will reconstruct the 3-D distribution of stars in and between these spiral arms, the 3-D distribution of the Galactic stellar warp and the disrupted dwarf galaxy, Argo, that lies behind, and the 3-D distribution of extinction in these directions. Given the close relationship between extinction and J=1 -> 0 CO emission, knowledge of the space distribution of extinction will permit us to tap the kinematic information in molecular line surveys to produce a direct and independent determination of the Galactic rotation curve beyond the Solar circle. Independently we can use stellar proper motions from the difference in USNO-A2.0 and 2MASS positions, combined with our Spitzer/2MASS individual photometric parallaxes to millions of stars, to validate the CO rotation curve. Recognizing the breadth of likely community interest in this dataset beyond the science outlined here, we will waive all Spitzer proprietary data rights.

Spitzer Space Telescope - General Observer Proposal #40983

IRS Observations of the Double Helix Nebula

Principal Investigator: Mark Morris
Institution: University of California, Los Angeles

Technical Contact: Mark Morris, University of California, Los Angeles

Co-Investigators:
Tuan Do, UCLA
Keven Uchida, JPL

Science Category: galactic structure
Observing Modes: IrsStare
Hours Approved: 7.1

Abstract:
We propose an IRS study of the Double Helix Nebula in the Galactic Center. This large-scale (30-pc) feature has been interpreted as a torsional Alfven wave driven by the rotation of the circumnuclear disk about the central black hole of the Galaxy. The cause of its infrared emission is likely to be thermal infrared emission by dust, but the mechanism by which the dust is organized into the observed helical structure is unknown. The proposed observations are aimed at learning as much as possible about the characteristics of the dust grains in this feature: their charge state, their size, and their temperature, in order to assess the hypothesis that the strong magnetic field at the Galactic center has played a role levitating the dust to its observed location, and ordering its morphology.

Spitzer Space Telescope - General Observer Proposal #20121

Solving the Microlensing Puzzle: A Spitzer/IRAC Approach

Principal Investigator: Brian Patten
Institution: Harvard-Smithsonian

Technical Contact: Brian Patten, Harvard-Smithsonian

Co-Investigators:
Charles Alcock, Harvard University
Nitya Kallivayalil, Harvard University
Michael Werner, JPL
Giovanni Fazio, Smithsonian Astrophysical Observatory

Science Category: galactic structure
Observing Modes: IracMap
Hours Approved: 6.7

Abstract:
We propose to use Spitzer/IRAC to obtain mid-IR photometry for 7 bona-fide LMC microlensing events seen in the original MACHO survey. The purpose of this survey is to assess the fraction of lensing objects which belong to some population of dwarf stars in the disk of our own Galaxy. Cool lens stars are revealed in the IRAC bandpasses via an infrared flux excess, a technique we have already used to show that the lens of event MACHO-LMC-5 is an ~M5 dwarf in a related GTO program. These data, in combination with existing Spitzer/IRAC GTO data and HST ACS data (proposed in HST Cycle 14), will be used to ascertain the basic properties of the lenses for all 15 true microlensing events from the original MACHO survey. These data will allow us to draw important conclusions as to what fraction of these events have lenses which belong to some population of dwarf stars in the disk and what fraction must be due to lenses in the halo or in the LMC itself. These data will greatly increase our understanding of the structure of the Galaxy by characterizing the stellar population responsible for the gravitational microlensing.

Spitzer Space Telescope - Directors Discretionary Time Proposal #462

Spitzer Heritage Project, Part 1.

Principal Investigator: Luisa Rebull
Institution: Spitzer Science Center

Technical Contact: Luisa Rebull, SSC

Co-Investigators:
Deborah Padgett, Spitzer Science Center
Gordon Squires, Spitzer Science Center
Robert Hurt, Spitzer Science Center
Lori Allen, Harvard/CfA

Science Category: galactic structure
Observing Modes: IracMap MipsScan
Hours Approved: 40.0

Abstract:
The finite lifetime of Spitzer's cryogen implies a limited opportunity to obtain full coverage of well-known and popular objects. We searched the Spitzer archive for observations of such targets that are either incomplete in spatial coverage, have gaps in the coverage maps, or are missing observations in valuable passbands. We propose to obtain observations of these regions to enhance the legacy value of Spitzer observations of some of the best known objects in the sky. Recognizing the value of completing these observations for both professional astronomers and the general public alike, we waive the proprietary period. This proposal is to enhance Spitzer's "Heritage" value for scientists and the general public, and as such we request a Director's Discretionary Time allocation.

Spitzer Space Telescope - Directors Discretionary Time Proposal #104

First Look Survey - Galactic Component

Principal Investigator: Tom Soifer
Institution: Spitzer Science Center

Technical Contact: Deborah Padgett, California Institute of Technology

Science Category: galactic structure
Observing Modes: IracMap MipsScan
Hours Approved: 35.7

Abstract:
The galactic component of the SIRTF First Look Survey is intended to characterize diffuse emission and point source confusion at a variety of galactic latitudes and in a typical molecular cloud. The strategy involves sparse mapping in 15 arcmin x 1 degree strips with MIPS and IRAC along galactic longitudes 105.6 (galactic latitudes -1.3,0.35, 2.0,4.0,8.0,16.0, and 32.0 degrees) and 254.4 degrees (galactic latitudes 0.0,-2.0,-5.0,-9.0, and -14.0 degrees). In addition, four small IRAC maps at galactic longitude 97.5 (galactic latitudes 0,-4,+4, and +16) will be made to best sample the stellar density of the Galactic disk. The L1228 molecular cloud will be mapped with a 10 arcmin x 2 degree strip with MIPS and IRAC.

Spitzer Space Telescope - General Observer Proposal #30907

Searching for Dust in Compact High-Velocity Clouds

Principal Investigator: Rik Williams
Institution: The Ohio State University

Technical Contact: Rik Williams, The Ohio State University

Co-Investigators:
Smita Mathur, The Ohio State University
Fabrizio Nicastro, Harvard-Smithsonian Center for Astrophysics
Martin Elvis, Harvard-Smithsonian Center for Astrophysics

Science Category: galactic structure
Observing Modes: MipsPhot MipsScan
Hours Approved: 8.1

Abstract:
Although neutral hydrogen high velocity clouds (HVCs) have been known to exist for over 40 years, surprisingly little is known about their physical properties such as distance, mass and size. Whether HVCs reside in the Galactic halo or in the larger scale Local Group medium has long been a matter of debate and studies of compact HVCs are likely to provide us with a piece of the puzzle. We propose Spitzer observations of three well chosen compact HVCs with the aim of detecting dust emission from them. Detection of dust in our compact high velocity clouds will have profound implications. It would imply that a good fraction of gas in the compact HVCs is in compact, dense clumps. The current theoretical framework holds that most mass accreted onto the Milky Way is in the form of diffuse gas, resulting from the cooling of a hot halo. This picture will change significantly with positive Spitzer detecions. Moreover, the inferred mass in compact HVCs may be significantly larger than that found from HI observations alone, to be compared with about one solar mass per year accretion rate needed to explain a variety of Galactic phenomena such as the star formation rate and the distribution of stellar metallicities with age. Spitzer non-detections would be valuable as well. We expect to detect dust in these CHVCs if their properties are typical of nearby compact lower--velocity clouds. A non-detection would place these compact HVCs much farther away, more into the Local Group environment. This may be consistent with the extremely low velocity in the Local Group rest frame for one of our targets. This would support the Local Group deployment model of compact HVCs and numerial simulations. Thus, Spitzer observations of compact HVCs would play a vital role in our understanding of galaxy formation and/or the larger scale structure of the Local Group, with possible implications for the "missing satellite" problem inherent in cold dark matter simulations of structure formation.

Spitzer Space Telescope - Directors Discretionary Time Proposal #485

The Spitzer Spectroscopic Stellar Atlas

Principal Investigator: David Ardila
Institution: Spitzer Science Center

Technical Contact: David Ardila, SSC

Co-Investigators:
Schuyler van Dyk, SSC
John Stauffer, SSC
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Inseok Song, SSC
Stephanie Wachter, SSC
Sergio Fajardo-Acosta, SSC
Donald Hoard, SSC
Carl Grillmair, SSC
Mark Lacy, SSC

Science Category: stellar populations
Observing Modes: IrsStare
Hours Approved: 29.2

Abstract:
We propose to compile a low-resolution stellar atlas, sampling all regions of the HR diagram. The goal of the atlas is to provide templates for models of galaxy evolution, as well as calibrators for future space missions. In addition, the targets are intrinsically interesting: little is known about variation of spectral features with spectral or luminosity class. A search of the Spitzer archive reveals stellar classes that have been neglected in GO, GTO, or Legacy proposals. Such classes include hypergiants, supergiants, bright giants, giants, and high-mass dwarfs. This proposal seeks to obtain data that will complement that already in the Spitzer archive. The union of the two will provide a lasting Spitzer legacy.

Spitzer Space Telescope - General Observer Proposal #20807

Spitzer Imagery & Spectroscopy of Symbiotics with Extended Nebulosity.

Principal Investigator: Frederick Bruhweiler
Institution: Catholic Univ. of America

Technical Contact: Frederick Bruhweiler, Catholic Univ. of America

Co-Investigators:
Glenn Wahlgren, Univ. of Lund
Mattias Eriksson, Univ. of Lund
Ekaterina Verner, Catholic Univ. of America
Bruce McCollum, IPAC/Caltech

Science Category: stellar populations
Observing Modes: IrsStare MipsPhot
Hours Approved: 22.4

Abstract:
The interacting binaries known as symbiotics defy easy placement in our picture of binary stellar evolution. It is unresolved if these objects are more akin to recurrent novae or nuclei of PNe. Optical and radio imagery reveal that many symbiotics have extended ionized nebulosities stemming from recent and prior ourbursts. We will use Spitzer to obtain MIPS 24 and 70 micron imagery and IRS SH and LH spectroscopy of seven (7) symbiotics showing nebulosity with extent greater than 10". Our combined spectroscopic and imaging program has the following goals. 1.)From MIPS imagery, we will use the dust emission to more fully delineate the enshrouding ejecta. This will sample ejecta near the symbiotic and also at much greater distances, associated with older outbursts. Morphological comparisons for individual objects will give information on whether the nebulae are analogous to nova shells or PN. 2.) From IRS spectra, we will determine the characteristics of the dust through presence of crystalline silicates and possibly other discrete dust features in the spectrum. 3.) We will use this to ascertain the dust properties, environment, and chemistry at time of dust formation. This will greatly expand our knowledge of how symbiotics contribute to dust and elemental enrichment of the Galactic ISM. We will use the high ionization forbidden lines in IRS spectra and our photoionization modeling to derive the SED and the nature of the hot ionizing source in symbiotics. We will further use photoionization modeling, plus spectral data at other wavelengths, to derive reliable abundances both in the high-ionization region and in the low-ionization emission region giving rise to the rich Fe II spectrum typical of symbiotics. Our three-pronged complementary investigation of mapping morphology, characterizing the dust, and abundance analysis, provides an unprecedented means to determine the physical processes in, and evolutionary phases of, symbiotics.

Spitzer Space Telescope - Directors Discretionary Time Proposal #464

Matching the Absolute Calibrations of WISE and Spitzer

Principal Investigator: Martin Cohen
Institution: MIRA

Technical Contact: Martin Cohen, MIRA

Co-Investigators:
The WISE Science Team ,

Science Category: stellar populations
Observing Modes: IracMap MipsScan MipsPhot IrsStare
Hours Approved: 12.5

Abstract:
The Wide-field Infrared Survey Explorer (WISE), a Medium Explorer currently in Phase C/D, will survey the entire sky to 0.12/0.16/ 0.65/2.6 mJy (5 sigma) at 3.3/4.7/12/23 microns. WISE will observe the north and south ecliptic poles (NEP and SEP) on nearly every orbit, making these ideal calibration fields. The WISE science team requests Spitzer Director's Discretionary Time to survey the NEP with MIPS, the SEP with MIPS and IRAC, and to obtain IRS and MIPS observations of Spitzer calibration stars that are candidate WISE standards. The purposes of these observations are to: - develop new calibrators very close to the SEP; - confirm the photospheric character of potential NEP/SEP WISE calibrators with IRS spectroscopy; - assess the long-term stability for WISE of non-primary IRAC standards; - identify objects that will saturate the WISE arrays in the most frequently observed polar regions. These Spitzer observations should be completed as soon as possible to allow followup ground-based optical classification spectroscopy and photometry, prior to the WISE launch in November 2009.

Spitzer Space Telescope - Directors Discretionary Time Proposal #472

IRS spectroscopy of candidate SEP WISE standards

Principal Investigator: Martin Cohen
Institution: UC Berkeley

Technical Contact: Martin Cohen, UC Berkeley

Science Category: stellar populations
Observing Modes: IrsStare
Hours Approved: 3.5

Abstract:
This proposal is to use IRS to observe stars in the WISE single field-of-view (FOV) at the SEP and supplements our previously accepted DDT proposal in support of WISE calibration stars. The stars in this continuation proposal were approved in principle by our meeting with the ISTs, but we were advised to withdraw our SEP "generic" sources and resubmit once we had identified the target stars by name. This we have done. This small proposal completes our request for DDT time in support of WISE. As was the case in our original DDT proposal ands its revised version this proposal is supported by the entire WISE Science Team.

Spitzer Space Telescope - General Observer Proposal #3725

A Spitzer Space Telescope/IRAC Database of Globular Clusters: Calibration of population synthesis models in the mid-IR

Principal Investigator: Paul Goudfrooij
Institution: Space Telescope Science Institute

Technical Contact: Paul Goudfrooij, Space Telescope Science Institute

Co-Investigators:
Thomas Puzia, Space Telescope Science Institute
Rupali Chandar, Space Telescope Science Institute

Science Category: stellar populations
Observing Modes: IracMap
Hours Approved: 19.8

Abstract:
Globular clusters are simple stellar populations which provide fundamental age/metallicity templates for the interpretation of galaxy properties. We are collecting a large, multi-wavelength dataset for a number of Galactic globular clusters and intermediate-age (> 0.5 Gyr), populous clusters in the Large Magellanic Cloud. The dataset will include UV (GALEX), optical (SDSS), and near-IR (2MASS) imaging as well as ground-based spectroscopy from 3800-9000 A. All of the targets have high-quality age and metallicity determinations available. To complete this comprehensive dataset (which will be made available to the community), we propose to obtain high-quality mid-IR IRAC photometry of 24 Galactic and LMC clusters. Our immediate goals are to: (1) use the IRAC measurements of the clusters' integrated light to obtain a unique color-metallicity relation for integrated light measurements in the 2-8 micron region; (2) use the 2MASS and IRAC images to create color-magnitude and color-color diagrams of the bright RGB and AGB stars to quantify the relative contributions of photospheric and circumstellar dust excess emission in the 8-micron passband as a function of metallicity. These data will provide an important empirical baseline for the interpretation of galaxy colors in the mid-IR, as well as a sanity check for synthetic colors produced by population synthesis models.

Spitzer Space Telescope - General Observer Proposal #20818

The Initial Mass Function in the Outer Galaxy: The star forming region NGC 1893

Principal Investigator: Giuseppina Micela
Institution: INAF-Osservatorio Astronomico di Palermo

Technical Contact: John Stauffer, Spitzer Science Center

Co-Investigators:
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Rick Harnden, SAO
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Salvatore Sciortine, INAF-OAPA
John Stauffer, IPAC/Caltech
Antonnella Vallenari, INAF-OAPD
Scott Wolk, CXC
Fabio Favata, ESA

Science Category: stellar populations
Observing Modes: IracMap
Hours Approved: 2.0

Abstract:
We will explore the effects of environmental conditions, which change dramatically between the inner and outer regions of the Galaxy, on the initial mass function (IMF) of the star forming region NGC 1893. Our proposed 450ksec observation of NGC 1893, a SFR of ~3 Myr in the outer part of the Galaxy, joint with two hours of Spitzer data, will permit us to identify members down to 0.5 Msun and enable a comparison of NGC 1893's IMF with those derived for SFRs in the solar neighborhood. Our observations will help in determining, particularly in the low mass regime, how the IMF depends on galactic environment. With its spatial resolution and sensitivity, Chandra, with the support of Spitzer, is uniquely suited to achieve our objectives.

Spitzer Space Telescope - Archive Research Proposal #40106

Improving the Photometric Precision of IRAC Channels 1 & 2

Principal Investigator: Kenneth Mighell
Institution: National Optical Astronomy Observatory (NOAO)

Technical Contact: Kenneth Mighell, NOAO

Co-Investigators:
William Hoffmann, Steward Observatory / University of Arizona
William Glaccum, Caltech/Spitzer Science Center

Science Category: stellar populations
Dollars Approved: 73081.0

Abstract:
During the past year, the Principal Investigator has worked closely with Spitzer's Infrared Array Camera (IRAC) Instrument Team to demonstrate that his NASA- funded MATPHOT algorithm for precision stellar photometry and astrometry can yield an improvement in the precision of stellar photometry obtained from IRAC Ch1 observations of bright stars of more than 100% over the best results obtained with aperture photometry using the calibration procedures recommended in the IRAC Data Handbook. We propose to analyze archival observations of bright stars obtained with IRAC Ch1 and Ch2 with the goal of developing new calibration procedures that have the potential of significantly improving the precision of point-source photometry. This timely research effort is intended to enhance the science return not only of existing IRAC Ch1 and Ch2 observations in the Spitzer data archive but also those that will be made during Spitzer's warm mission which will start around April 2009 after all of the cryogen is depleted. One or more articles describing the new calibration procedures will be submitted for publication in the refereed literature no later than 1 October 2008; the results of this archival research effort will also be presented to the space science community at scientific conferences and posted on a web site dedicated to this project on the web servers of the National Optical Astronomy Observatory.

Spitzer Space Telescope - General Observer Proposal #3549

Ultracool Brown Dwarfs and Massive Planets Around Nearby White Dwarfs

Principal Investigator: Eric Becklin
Institution: University of California, Los Angeles

Technical Contact: Eric Becklin, University of California, Los Angeles

Co-Investigators:
Ben Zuckerman, University of California, Los Angeles
Jay Farihi, University of California, Los Angeles

Science Category: compact objects
Observing Modes: IracMap
Hours Approved: 7.0

Abstract:
White dwarfs are excellent targets for ultracool brown dwarf and massive planet searches. These Earth-size stars have intrinsically low luminosities and provide very high contrast when looking for Jupiter-size companions in the infrared. A few brown dwarfs are seen around white dwarfs and planets are seen around their progenitors. Spitzer/IRAC will enable an infrared survey of these faint post main sequence stars which is impossible from the ground due to a large thermal background. Sensitivities are sufficient to detect sub T dwarf brown dwarfs and planets having temperatures as low as 300 K. At our greatest sensitivity we will be able to image orbiting bodies with masses as small as five Jupiters - providing an opportunity to directly image extrasolar planets.

Spitzer Space Telescope - General Observer Proposal #50600

The First Mid-Infrared Spectrum of a Low Mass X-Ray Binary

Principal Investigator: Joel Bregman
Institution: Univerisity of Michigan

Technical Contact: Joel Bregman, Univerisity of Michigan

Co-Investigators:
Jon Miller, University of Michigan
Ed Cackett, University of Michigan

Science Category: compact objects
Observing Modes: IrsStare
Hours Approved: 3.1

Abstract:
Roche lobe overflow from a low-mass star to a neutron star produces immense amounts of continuum radiation from an accretion disk. The accretion disk emits primarily in the X-ray region, although the outer part of the disk dominates the emission in the UV-optical region, and the Rayleigh-Jeans tail extends into the mid-infrared region, as seen in Sco X-1. Line emission is also important, as it reveals critical properties of the accretion disk, the hot wind (if present), and the local environment. Line emission in the mid-infrared has never been observed for any LMXB but it can provide critical insights to the object's environment. For the first time, we propose to measure mid-IR lines from a LMXB by using the best target, Sco X-1, the brightest persistent X-ray source in the sky.

Spitzer Space Telescope - General Observer Proposal #20669

Search for Non-Thermal Emission in a Quiescent Black-Hole X-ray Binary

Principal Investigator: Michelle Buxton
Institution: Yale University

Technical Contact: Michelle Buxton, Yale University

Co-Investigators:
Charles Bailyn, Yale University

Science Category: compact objects
Observing Modes: IracMap
Hours Approved: 0.2

Abstract:
Accretion flow in X-ray binaries, particularly during quiescence, has been claimed to produce evidence for the existence of event horizons (Garcia et al. 2001) and other direct tests of strong-field relativity (Cui, Zhang & Chen 1998). However, the basic physical processes are still poorly understood. Traditionally it has been thought that the quiescent flux is dominated by the secondary star. However, light curve models show that the secondary star alone cannot account for the quiescent flux. Flux from accretion disks have been included in such models, but these are not always successful in explaining the light curve morphology. Alternatively, some of the flux may be due to the presence of synchrotron emission which most likely originates from jets. If non-thermal emission is present in X-ray binaries during quiescence it may provide the best constraint on the quiescent accretion flow. This proposal seeks to observe a quiescent black-hole X-ray binary to determine if non-thermal emission is present.

Spitzer Space Telescope - General Observer Proposal #30822

Fallback Debris Disks Around Neutron Stars

Principal Investigator: Deepto Chakrabarty
Institution: Massachusetts Institute of Technology

Technical Contact: Deepto Chakrabarty, MIT

Co-Investigators:
Zhongxiang Wang, MIT
David Kaplan, MIT

Science Category: compact objects
Observing Modes: IracMap
Hours Approved: 14.8

Abstract:
Our Spitzer/IRAC discovery of a dusty debris disk around the young neutron star 4U 0142+61 is the first detection of a fallback disk around a neutron star. Fallback, the notion that some material from a supernova explosion could remain bound to the compact remnant, is a general prediction of core-collapse supernova models, yet until now there were few if any meaningful observational constraints on the size (or existence) of such disks. Here we propose to test the ubiquity of such disks with deep IRAC observations of two young neutron stars, each a representative of a different class of object (a rotation-powered pulsar and a radio-quiet neutron star in a supernova remnant). We will examine whether fallback disks are common to all neutron stars or depend on the factors that separate these classes. Our proposed observations will pave the way for future surveys and in-depth investigations of individual objects.

Spitzer Space Telescope - General Observer Proposal #40925

Fallback Debris Disks Around Young Neutron Stars

Principal Investigator: Deepto Chakrabarty
Institution: Massachusetts Institute of Technology

Technical Contact: Deepto Chakrabarty, MIT

Co-Investigators:
David Kaplan, MIT
Zhongxiang Wang, McGill University
Stefanie Wachter, Spitzer Science Center

Science Category: compact objects
Observing Modes: IracMap MipsPhot
Hours Approved: 32.6

Abstract:
Our Spitzer/IRAC discovery of a dusty debris disk around the young neutron star 4U 0142+61 is likely the first detection of a supernova fallback disk around a neutron star. Here we propose to test three aspects of this hypothesis with targeted Spitzer observations: (1) IRAC imaging of the magnetar 1E 2259+586, to see if debris disks are ubiquitous; (2) deep MIPS 24 micron imaging of 4U 0142+61 to probe the long-wavelength tail of the disk and measure its radial extent; and (3) IRAC subarray observations of 4U 0142+61 designed to detect for 8.7 sec pulsations or set an upper limit on their amplitude. This last measurement will allow us to definitively discriminate whether the mid-IR emission arises from an X-ray heated debris disk or the pulsar magnetosphere.

Spitzer Space Telescope - General Observer Proposal #3655

Searching the Stellar Graveyard for Planets and Brown Dwarfs with SST

Principal Investigator: John Debes
Institution: Pennsylvania State University

Technical Contact: John Debes, Pennsylvania State University

Co-Investigators:
Steinn Sigurdsson, Penn State University

Science Category: compact objects
Observing Modes: IracMap
Hours Approved: 9.7

Abstract:
We propose a small observing program to search nearby hydrogen white dwarfs with metal lines (DAZs) for mid-IR excesses due to dusty disks or substellar companions. At first glance White Dwarfs (WDs) seem to be an unlikely population to search for planets and substellar objects, but recent theoretical and observational research predicts that DAZs are markers for substellar systems and dusty disks. WDs then become an ideal target for ‘‘forensic planetology’’, we can infer aspects of planet formation from these ‘‘dead’’ systems that span a large range of initial stellar mass. These considerations have motivated us to propose for high contrast imaging searches for faint companions to DAZs in the near-IR with NICMOS on HST. IRAC photometry on SST ideally complements a high spatial resolution search, both by confirming candidate substellar objects already detected by our HST program and by probing deeper at unresolved distances through the detection of mid-IR excesses due to substellar companions. We estimate that 15 M$_{jup}$ companions will be able to be detected as unresolved excesses, and 5-7M_{jup} companions will be able to be detected at spatial separations $>$ 3arcsec. Results from this program will help our understanding of the brown dwarf desert, the frequency and effects of common envelope evolution, planet formation and evolution, and the fraction of stars with planets or habitable planets.

Spitzer Space Telescope - Directors Discretionary Time Proposal #533

Spectroscopic survey of 24 microns selected dust-free SNR candidates

Principal Investigator: Nicolas Flagey
Institution: Spitzer Science Center

Technical Contact: Nicolas Flagey, Spitzer Science Center

Co-Investigators:
Nicolas Billot, NHSC
Sean Carey, SSC/CAltech
Alberto Noriega-Crespo, SSC/Caltech
Sachin Shenoy, SSC/Caltech
Donald Mizuno, USAF
Kathleen Kraemer, USAF
Bill Latter, NHSC/Caltech
Joe Hora, Harvard-Smithsonian CfA

Science Category: compact objects
Observing Modes: IrsStare
Hours Approved: 5.6

Abstract:
Over 400 diffuse emission bubbles have been identified at 24 microns from visual inspection of the MIPSGAL Legacy Survey (Carey et al. 2009) mosaic images. These small (< 1 arcminute) rings, bubbles, disks or shells are pervasive through the entire Galactic plane in the mid-infrared. Their distribution is approximately uniform in Galactic latitude and longitude, and the average density is found to be around 1.5 bubbles per square degree. Analysis of GLIMPSE 3.6 to 8.0 microns and MIPSGAL 70 microns images indicates that a large majority of these objects are only detected at 24 microns. The usual suspects for these "bubbles" are some type of evolved stars (PNe, SNRs, WR, AGB ...). Extensive browsing of available catalogs have allowed us to identify less than 10% of these objects. The majority of the already known "bubbles" were found to be PNe. Three SNRs and one post-AGB star were also identified. Therefore, about 90% of the objects within our catalog are new discoveries. Very recent Spitzer/IRS low-resolution observations of two objects analog to our "bubbles" have provided us with a new perspective. They both show dust-free, highly-ionized-gas-rich spectra. While these two spectra share some striking characteristics, they are like nothing published before and they also exhibit significant differences between each other in terms of ionized gas line ratios. One of these objects has been suggested to be a distant dust-free young surpernova remnant. Whatever the nature of these 24 microns sources are, the implications of such a large number in the Galactic plane is profound. This project has a high discovery potential, particularly if a majority of these "bubbles" are dust-free SNRs. We propose IRS high-resolution observations of a selected subsample of 21 "bubbles" in order to determine their physical nature. This survey of a statistically representative number of objects is the only way to glean information on the ensemble. Spitzer/IRS is the only instrument in the near future that is capable of probing the very

Spitzer Space Telescope - General Observer Proposal #20074

Structure and Evolution of Compact Binary Systems: Infrared Spectroscopy of SS Cygni

Principal Investigator: Cynthia Froning
Institution: University of Colorado

Technical Contact: Cynthia Froning, University of Colorado

Co-Investigators:
Guillaume Dubus, Institut d'Astrophysique de Paris
Knox Long, Space Telescope Science Institute
Paula Szkody, University of Washington
Ron Taam, Northwestern University
Hendrik Spruit, Max Planck Institute for Astrophysics
Donald Hoard, Spitzer Science Center
Steve Howell, NOAO
David Ciardi, IPAC
Gerard van Belle, IPAC
Stefanie Wachter, Spitzer Science Center

Science Category: compact objects
Observing Modes: IrsStare
Hours Approved: 7.1

Abstract:
Cataclysmic variables (CVs) are interacting binary systems in which a white dwarf accretes mass from a late-type donor star. In dwarf novae (DN), accretion occurs via a disk around the white dwarf that undergoes semi-regular outbursts caused by thermal-viscous disk instabilities. Because of their proximity and lack of obscuration, CVs are excellent systems in which to study the physics of disk accretion and binary star evolution. Ground-based mid-IR (4 -- 18 micron) photometry of the quiescent DN SS Cygni revealed a flux well in excess of that expected from the accretion disk and the donor star. The IR emission also appeared to vary on 15~min timescales, although the limited sensitivity of the ground-based observations precluded detailed variability study. The source of this emission is not known. Possible IR emission regions in DN include circumbinary material, a remnant of the common envelope evolutionary phase of the binary; a previously unobserved component of the accretion disk; or an outflow from the disk or the donor star. We propose Spitzer IRS staring mode observations to identify and characterize the source of the quiescent IR emission in SS Cyg. We will use the observations to study both the high S/N, time-averaged spectrum of the IR source and to construct time-resolved lightcurves in multiple wavebands. The spectra and lightcurves will allow us to distinguish between circumbinary emission, likely to be cold and dusty, and a disk or outflow source, which will be warmer and possibly show molecular and/or shocked gas emission features. Spitzer is the only instrument capable of obtaining these data, which will enable us to open a new window on the accretion physics and evolution of CVs.

Spitzer Space Telescope - General Observer Proposal #20232

Mid-Infrared and multi-wavelength monitoring of the microquasar GRS 1915+105.

Principal Investigator: Yael Fuchs
Institution: Service d'Astrophysique CEA/Saclay

Technical Contact: Jerome Rodriguez, Service d'Astrophysique CEA/Saclay

Co-Investigators:
Jerome Rodriguez, CEA/Saclay, France & ISDC, Geneva, Switzerland
Sylvain Chaty, Universite Paris 7 & CEA/Saclay, France
Hannikainen Diana, University of Helsinki, Finland
Felix Mirabel, CEA/Saclay & ESO, Santiago, Chile
Marc Ribo, CEA/Saclay, France
Vivek Dhawan, NRAO/Socorro
Michael Rupen, NRAO/Socorro
Guy Pooley, MRAO, Cavendish Laboratory, Cambdridge, UK

Science Category: compact objects
Observing Modes: IracMap IrsStare
Hours Approved: 4.1

Abstract:
We propose to continue mid-infrared photometric and spectroscopic observations of the microquasar GRS 1915+105 in the context of a campaign of multi-wavelength observations of the source. GRS 1915+105 is used as a laboratory to understand the accretion / ejection phenomena occurring in stellar-mass accreting black hole (microquasars) and by analogy in supermassive black holes (AGNs). A key question is the nature of the time-variable infrared emission in this system. Depending on the state of the source, we wish to know what is the contribution in the mid-infrared of the different possible emission mechanisms: the thermal emission from the K-M giant donor star, the synchrotron emission from the compact relativistic jets, X-ray reprocessing in the accretion disc and free-free emission from a possible disc-wind. The continuum in a wavelength range as large as possible and the possible emission lines observed thanks to the Infrared Array Camera (IRAC) and the Infrared Spectrograph (IRS) are important clues to achieve this study. These mid-infrared observations will be combined with observations with the RXTE and INTEGRAL satellites in the X-rays and gamma-rays, the ESO/NTT in near-infrared and the VLA/VLBA and Ryle Telescopes in radio. Thanks to these simultaneous multiwavelength observations we will identify the accretion state of the source and determine the contribution of each emission component of the system. As GRS 1915+105 had been rarely observed in the mid-infrared range in the past, the Spitzer Space Telescope brings the unique opportunity to do so, shedding light on the physical mechanisms occurring in this particular binary system and which could apply to the other black hole binaries.

Spitzer Space Telescope - General Observer Proposal #3352

Mid-Infrared and multi-wavelength monitoring of the microquasar GRS 1915+105.

Principal Investigator: Yael Fuchs
Institution: Service d'Astrophysique CEA/Saclay

Technical Contact: Yael Fuchs, Service d'Astrophysique CEA/Saclay

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Hannikainen Diana, University of Helsinki, Finland
Felix Mirabel, CEA/Saclay & IAFE / CONICET, Argentina

Science Category: compact objects
Observing Modes: IracMap IrsStare
Hours Approved: 4.4

Abstract:
We propose mid-infrared photometric and spectroscopic observations of the microquasar GRS 1915+105 in the context of a multi-wavelength follow-up campaign of the source. GRS 1915+105 is used as a laboratory to understand the accretion / ejection phenomena occurring in stellar-mass accreting black hole (microquasars) and by analogy in supermassive black holes (AGNs). A key question is the nature of the time-variable infrared emission in this system. Depending on the state of the source, we wish to know what is the contribution in the mid-infrared of the different possible emission mechanisms: the thermal emission from the K-M giant donor star, the synchrotron emission from the compact relativistic jets, X-ray reprocessing in the accretion disc and free-free emission from a dense wind. A particular contribution of the Spitzer Telescope will be the observation of this dense wind in GRS 1915+105, which is very difficult to detect in X-ray spectra due to pile-up phenomena in X-ray detectors. The continuum in a wavelength range as large as possible and the possible emission lines observed thanks to the Infrared Array Camera (IRAC) and the Infrared Spectrograph (IRS) are important clues to achieve this study. These mid-infrared observations will be combined with observations with the RXTE and INTEGRAL satellites in the X-rays and gamma-rays, the ESO/NTT in near-infrared and the Ryle Telescope in radio. Thanks to these simultaneous multiwavelength observations we will identify the accretion state of the source and determine the contribution of each emission component of the system. As GRS 1915+105 had been rarely observed in the mid-infrared range in the past, the Spitzer Space Telescope will bring the unique opportunity to do so, shedding light on the physical mechanisms occurring in this particular binary system and which could apply to the other black hole binaries.

Spitzer Space Telescope - General Observer Proposal #40948

Determining Stellar Black Hole Masses: Assessing the Non-Stellar Infrared Component of Black Hole Systems

Principal Investigator: Dawn Gelino
Institution: California Institute of Technology

Technical Contact: Christopher Gelino, California Institute of Technology

Co-Investigators:
Thomas Harrison, New MexicoState University
Chris Gelino, Spitzer Science Center

Science Category: compact objects
Observing Modes: IracMap
Hours Approved: 3.1

Abstract:
We propose to use the IRAC camera array on Spitzer to obtain mid-infrared observations of five black hole low mass X-ray binaries (LMXBs). Stellar black hole masses and their distributions are important inputs for binary evolution and supernova models. The current main limiting factor in determining accurate black hole masses is the uncertainty in the orbital inclination angle of the LMXB system due to an unknown amount of contaminating light in the near-IR (NIR). This light dilutes the ellipsoidal variations of the secondary star. It has been generally thought that the NIR ellipsoidal light curves of these systems were relatively uncontaminated; however, recent disk and jet models have thrust this thinking into question. The data obtained with IRAC will be combined with our previously obtained ground-based optical/NIR SEDs of each system to characterize and derive the amount of light contaminating the NIR ellipsoidal variations. Once this quantity is known, accurate orbital inclination angles and BH masses can be determined. With 900 seconds of observation time per target, this entire program requires a total of 3.1 hours of Spitzer time.

Spitzer Space Telescope - General Observer Proposal #50670

A mid-IR look at Z sources: Jets in neutron star X-ray binaries?

Principal Investigator: Dawn Gelino
Institution: California Institute of Technology

Technical Contact: Dawn Gelino, California Institute of Technology

Co-Investigators:
Stefanie Wachter, California Institute of Technology
Michael Rupen, NRAO
Sera Markoff, Anton Pannoekoek, University of Amsterdam

Science Category: compact objects
Observing Modes: IracMap MipsPhot
Hours Approved: 2.9

Abstract:
We propose to use the IRAC and MIPS camera arrays on Spitzer to establish the mid-infrared spectral energy distribution and search for evidence for jet emission contributions at Spitzer wavelengths for three Z sources: GX 349+2, GX 17+2, and Cyg X-2. These neutron star X-ray binaries are the brightest X-ray sources in the Galaxy and also the most radio bright of their class. Their inferred high mass accretion rates make them the neutron star analog of black hole systems that exhibit prominent compact and transient jets. By modeling simultaneous broadband IR - radio data from Spitzer and the VLA, we can better understand the contribution of jets to the overall spectrum of these sources and investigate potential differences in the jet formation between black hole and neutron star systems.

Spitzer Space Telescope - General Observer Proposal #20551

The Nature of Ultraluminous X-ray Sources

Principal Investigator: Parviz Ghavamian
Institution: Johns Hopkins University

Technical Contact: Parviz Ghavamian, Johns Hopkins University

Co-Investigators:
Tim P. Roberts, University of Leicester
Edward J. M. Colbert, Johns Hopkins University
John C. Raymond, Harvard-Smithsonian Center for Astrophysics
William Pl Blair, Johns Hopkins University
Ravi Sankrit, Johns Hopkins University

Science Category: compact objects
Observing Modes: IrsStare
Hours Approved: 12.5

Abstract:
We propose IRS spectroscopy of nebular emission surrounding four nearby known ultraluminous X-ray sources (ULXs). The X-ray emission from these sources is produced by accretion onto stellar mass black holes with super-Eddington/beamed X-ray radiation, or intermediate mass black holes (> 100 M_sun) emitting isotropically. The nebular emission around the targeted ULXs consists of (1) known or suspected photoionized regions heated by disk emission from the central source, and (2) large (> 100 pc) shells driven by superwinds/multiple supernovae, or a single hypernova event. Our spectra will simultaneously sample the photoionized and shocked emission in these objects, and provide both valuable constraints on the ionizing spectrum of the accretion disk and the mass of the central black hole. In addition, intercomparison of our results will help clarify which mechanisms lead to ULX formation.

Spitzer Space Telescope - General Observer Proposal #3309

A search for second generation planetary systems around white dwarf merger remnants

Principal Investigator: Bradley Hansen
Institution: UCLA

Technical Contact: Bradley Hansen, UCLA

Co-Investigators:
Shri Kulkarni, California Institute of Technology

Science Category: compact objects
Observing Modes: IracMap
Hours Approved: 3.1

Abstract:
We propose to search for infrared excesses around a sample of ultramassive white dwarfs. Several lines of evidence suggest that these stars may be the result of the merger of close white dwarf binaries. Such mergers are likely to leave behind circumstellar disks rich in heavy elements. Our program is designed to detect the resulting dust disk through the reprocessed stellar light. Detection of such systems would suggest a new niche in the extrasolar planet parameter space - the possibility of the formation of second generation planetary systems.

Spitzer Space Telescope - General Observer Proposal #20003

The First Direct Measurement of the Magnetic Fields in the White Dwarfs of Intermediate Polars: Spectroscopy of their Mid-Infrared Cyclotron Features

Principal Investigator: Thomas Harrison
Institution: New Mexico State University

Technical Contact: Thomas Harrison, New Mexico State University

Co-Investigators:
Steve Howell, NOAO/WIYN
France Cordova, University of California, Riverside
Ryan Campbell, New Mexico State University
Michael Sussman, New Mexico State University
Doug Hoffman, New Mexico State University

Science Category: compact objects
Observing Modes: IrsStare
Hours Approved: 9.8

Abstract:
Intermediate Polars (IPs) are a type of magentic cataclysmic variable that are believed to contain a magnetic white dwarf with a field strength of less than 10 MG. This weaker magnetic field allows the formation of an accretion disk, so IPs exhibit behavior that spans that of both magnetic, and non-magnetic cataclysmic variables. Yet we still do not have observational proof that the canonical model for IPs is correct: There has never been a direct determination of the magentic field strength for an IP system. The reasons for this are twofold. First, unlike the Polars, IPs do not go into deep quiescence where the photosphere of the white dwarf is visible. During those times it is straightforward to measure the magnetic field strength of a Polar due to the Zeeman splitting of the photospheric hydrogen lines. Secondly, due to the high magnetic fields in Polars, the cyclotron harmonics are visible in optical and near- infrared spectra. The lack of such features in the optical and near-infrared spectra of IPs suggests that the magnetic fields of the white dwarf are below 10 MG. If so, the "humps" from the cyclotron emission will occur in the mid-infrared. We propose to use the IRS on Spitzer to detect the mid-infrared cyclotron humps for the ten brightest IPs. Using spectra from the SL2, SL1 and LL1 modes, we will be able to directly determine the magnetic field strength in IPs for the first time. In addition, other parameters associated with the magnetic accretion (e.g., optical depth and plasma temperature) will also be derived. Our project requires 9.8 hrs of Spitzer time.

Spitzer Space Telescope - General Observer Proposal #40124

Cyclotron or Synchrotron? Additional IRS Spectroscopy of Three Intermediate Polars

Principal Investigator: Thomas Harrison
Institution: New Mexico State University

Technical Contact: Thomas Harrison, New Mexico State University

Co-Investigators:
Steve Howell, NOAO/WIYN
France Cordova, University of California, Riverside
Ryan Campbell, New Mexico State University

Science Category: compact objects
Observing Modes: IrsStare
Hours Approved: 8.2

Abstract:
Intermediate Polars are binary systems where a magnetic white dwarf accretes matter from a late-type, Roche lobe-filling secondary star. The standard model for IPs assumes that the magnetic field strength of the white dwarf is < 10 MG. If true, any cyclotron emission should occur in the mid-infrared region of the electromagnetic spectrum. In Cycle 2, we conducted a survey of IPs using the IRS on Spitzer and found no compelling evidence for the presence of cyclotron emission. We found that if cyclotron emission was occuring in the 5 to 14 micron bandpass, it constituted less that 0.5% of the bolometric luminosity of these systems (in the highly magnetic "Polars", the cyclotron emission can rival the bolometric luminosity of the system!). We did, however, detect longer wavelength (> 14 micron) mid-infrared excesses for EX Hya and V1223 Sgr. These excesses are consistent with cyclotron emission from a 1 MG field. Unfortunately, the S/N of the LL2 data were poor, and we lacked the longer wavelength (LL1) observations that would clinch the case for such emission. As part of our IP survey, we extracted archival observations of AE Aqr and confirmed that its mid-infrared spectrum is dominated by optically thin synchrotron emission. It is reasonable to suggest that the LL2 detections of EX Hya and V1223 Sgr can be explained by such emission. With better LL2 data, and new LL1 observations, we will be able to determine whether the standard low field model for IPs is correct, or whether IPs are synchrotron sources. New, higher S/N data is requested for V603 Aql to determine whether it has an optically thin cyclotron emission feature at 8 microns, and whether it has a similar long wavelength excess. Our program requests 8.2 hours of Spitzer time.

Spitzer Space Telescope - General Observer Proposal #3520

Observing the infrared jet in Cyg X1

Principal Investigator: Sebastian Heinz
Institution: MIT

Technical Contact: Michael Nowak, MIT

Co-Investigators:
Prof. Deepto Chakrabarty, Massachusetts Institute of Technology
Dr. Katja Pottschmidt, Integral Science Data Centre
Dr. Guy Pooley, Mullard Radio Astronomy Observatory
Dr. Michael A. Nowak, Massachusetts Institute of Technology
Dr. Sera Markoff, Massachusetts Institute of Technology
Dr. Joern Wilms, University of Warwick

Science Category: compact objects
Observing Modes: IrsStare
Hours Approved: 2.1

Abstract:
We propose to observe the IR synchrotron emission from the jet of the X-ray binary Cyg X-1 with the IRS low resolution spectrograph on the Spitzer Space Telescope. By linking a set of 4 IR observations at different times to simultaneous radio, X-ray, and optical observations of Cyg X-1, we will be able to determine the exact shape of the synchrotron spectrum as a function of X-ray and radio flux. Understanding the broad band spectrum of Cyg X-1 will enable us to test theoretical models for jet formation in black hole binaries and to constrain fundamental parameters of jet physics. It will also allow us to asses whether the broad band synchrotron emission from jets accounts for a fair fraction of the total emission from X-ray binaries in the so called ‘‘hard state’’, as suggested in recent models. Cyg X-1 is ideally suited for such a task due to its close proximity (2.1 kpc), the well studied nature of its accretion states, the persistent presence of its VLBI resolved jet, and our ongoing frequent monitoring campaign at radio, optical, and X-ray energies. In order to be able to disentangle the jet emission from the Galactic IR background and the Rayleigh-Jeans tail of the bright companion star, we request a total of 7568 seconds or 2.1 hours of observing time.

Spitzer Space Telescope - General Observer Proposal #50590

Dust Around Cygnus X-1

Principal Investigator: Dean Hines
Institution: Space Science Institute

Technical Contact: Dean Hines, Space Science Institute

Co-Investigators:
Alberto Noriega-Crespo, Spitzer Science Center
Julia Lee, CFA
Sebastian Heinz, Univ. Of Wisconsin, Madison

Science Category: compact objects
Observing Modes: IracMap MipsPhot
Hours Approved: 1.0

Abstract:
We propose IRAC and MIPS imaging of the immediate vicinity of the High Mass X-ray Binary and black hole (BH), Cygnus X-1 to examine the interaction between an outflow, which is apparently driven by jet activity, and the nearby interstellar medium. Previous observations with ISO found (warm) extended (~30") infrared emission centered on Cyg X-1, but suffered from low resolution and sensitivity. The IRAC and MIPS observations proposed here will examine the nature of infrared emission from Cyg X-1 in detail, and look for infrared emission associated with the bow-shock/bubble structure imaged in the radio and H-alpha (this feature lies just beyond the area imaged by ISO). Our proposed images, combined with existing IRS spectra, will help to elucidate the nature of the ISO-detected extended emission, and enable us to better evaluate the impact that Cyg X-1 has on its immediate environment.

Spitzer Space Telescope - General Observer Proposal #20221

Probing the Paradigm for Cataclysmic Variable Evolution: Circumbinary Disks in the Mid-Infrared

Principal Investigator: Donald Hoard
Institution: IPAC, California Institute of Technology

Technical Contact: Donald Hoard, IPAC, California Institute of Technology

Co-Investigators:
Steve Howell, WIYN Observatory
David Ciardi, Michelson Science Center
Stefanie Wachter, Spitzer Science Center
Paula Szkody, University of Washington
Kunegunda Belle, LANL
Carolyn Brinkworth, University of Southampton/SSC
Gerard van Belle, Michelson Science Center
Cynthia Froning, University of Colorado

Science Category: compact objects
Observing Modes: IracMap IrsPeakupImage IrsStare MipsPhot
Hours Approved: 12.6

Abstract:
The secular evolution of cataclysmic variables (CVs) is driven by the loss of orbital angular momentum. Two mechanisms are usually invoked to account for the dissipation of angular momentum: gravitational radiation and magnetic braking of the secondary star. However, this dual loss-mechanism scenario cannot completely account for the very large mass transfer rates inferred for some CVs or the large spread in mass transfer rates observed at a given orbital period (i.e., evolutionary state). An additional angular momentum loss mechanism is needed; a likely possibility is the presence of a circumbinary disk (CBD) surrounding the CV. The CBD would be large (up to several AU in radius) and cool (a few thousand K at the inner edge to less than 1000 K at the outer edge). Its peak emission occurs in the infrared. We propose to use Spitzer's unique capability to sensitively probe the mid-infrared in order to assemble spectral energy distributions for a sample of 8 CVs, which we can use to search for infrared excess indicative of the presence of a CBD. Our target objects span a variety of CV classes, but there is evidence that all of them have high mass transfer rates that could be driven by the presence of an additional angular momentum loss mechanism.

Spitzer Space Telescope - Directors Discretionary Time Proposal #299

Circumbinary Dust in Magnetic Cataclysmic Variables - Bright State of AM Her

Principal Investigator: Donald Hoard
Institution: Spitzer Science Center

Technical Contact: Donald Hoard, SSC

Co-Investigators:
Steve Howell, NOAO
Stefanie Wachter, SSC/Caltech
Carolyn Brinkworth, SSC/caltech

Science Category: compact objects
Observing Modes: IracMap
Hours Approved: 0.2

Abstract:
Observations by the AAVSO during the past several days of the polar AM Herculis show that it may be leaving the "normal" faint state it has occupied during the past ~2 years, and becoming bright. We observed AM Her with IRAC during GO-3 as part of program 30249. That program also included two medium-impact TOO observations to be triggered to re-observe any target of 30249 that changed brightness state during GO-3 from whatever state it was in when its non-TOO observation for 30249 was made. Unfortunately, those TOOs expired at the end of June, at about the same time that AM Her first started to show an indication that it might be getting bright. So, we are requesting a DDT observation, for the same scientific reasons that the TOO observations were requested (and approved) for program 30249 (to be detailed in a follow-on email to the Spitzer Helpdesk). The target is visible to Spitzer until Dec 2007 - we request the DDT observation during IRAC-43 or IRAC-44, in case the high state is of short duration. Total AOR duration will be ~10 minutes. We have requested that the AAVSO alert its members to intensify observations of AM Her so we can confirm with certainty the rise to bright state within the next few days; in the meantime, please consider this TOO request and notify us if it would be approved. By then, we should know if the rise to bright state is real and should be observed.

Spitzer Space Telescope - General Observer Proposal #30249

Circumbinary Dust in Magnetic Cataclysmic Variables - Exploring Polars in the Mid-Infrared

Principal Investigator: Donald Hoard
Institution: IPAC, California Institute of Technology

Technical Contact: Donald Hoard, IPAC, California Institute of Technology

Co-Investigators:
Carolyn Brinkworth, Spitzer Science Center
Stefanie Wachter, Spitzer Science Center
Steve Howell, WIYN Observatory/NOAO

Science Category: compact objects
Observing Modes: IracMap IrsStare
Hours Approved: 7.8

Abstract:
As part of our Spitzer GO1 programs, we obtained the first-ever mid-IR observations of strongly magnetic cataclysmic variables (CVs), known as polars. We found excess mid-IR flux in our IRAC data, suggesting the presence of a radiating component in addition to the WD and secondary star. We have tentatively identified this component as originating from circumbinary dust. These results demonstrate the unexpected signature of circumbinary dust in polars. This suggests that circumbinary dust disks may, in fact, be ubiquitous in CVs regardless of mass transfer or outburst history. Thus, our current proposal represents the culmination of our GO1-2 surveys of CVs, which together will provide a broad overview of the nature of circumbinary dust in magnetic and non-magnetic CVs, the characteristics of low mass stellar and substellar secondary stars in extremely evolved CVs, and the overlap between those population samples. Specifically, we propose a 3-part program. In Part 1, we will obtain IRS spectra of a polar observed by us during GO1. This polar was found to be much brighter in the mid-IR than expected, making IRS SL observations feasible. These data will allow us to extend and constrain our models for polars further into the mid-IR. In Part 2, we will obtain IRAC observations of 5 new polars, in order to further explore the range of system parameter space (orbital period, magnetic field strength, etc.) occupied by the polars as a class. Finally, in Part 3, we will use up to 2 medium impact TOOs to make a second IRAC observation of any polar that we observe in GO3 (plus one from GO1) if they transition between accretion states during GO3 following their initial observation. We will trigger the TOOs using ground-based monitoring.

Spitzer Space Telescope - General Observer Proposal #50068

Observing Novalike Cataclysmic Variables: Do the Nearest Hot Accretion Disks Have the Infrared Spectra We Expect?

Principal Investigator: Donald Hoard
Institution: IPAC, California Institute of Technology

Technical Contact: Donald Hoard, IPAC, California Institute of Technology

Co-Investigators:
Knox Long, Space Telescope Science Institute
Janet Drew, University of Hertfordshire
Christian Knigge, University of Southampton

Science Category: compact objects
Observing Modes: IracMap IrsStare IrsPeakupImage
Hours Approved: 18.3

Abstract:
Novalikes are a subclass of cataclysmic variables in which the mass transfer rate is sufficiently high that the disk that mediates mass transfer to the white dwarf primary star is nearly always in the hot-ionized state. As such, they are the closest and best examples of steady state accretion disks around a compact object. With one exception, IX Vel, none has been observed with Spitzer. This is unfortunate since observations with Spitzer can be used to check our expectation that the spectral energy distribution of the disk is dominated by its hot interior regions, and to establish the infrared spectra of these objects. Observations are sorely needed so that we can test the steady state accretion disk theory, constrain and improve accretion disk models, construct multi-wavelength models of such systems, and search for evidence of other luminous components, including material outside the disk (e.g., in a wind, circumbinary disk, and/or the donor star). Here we propose to rectify this oversight by observing a small sample of novalike cataclysmic variables with IRS and IRAC to establish the universality of the spectrum and to explore differences in the spectra that are likely to be associated with orbital period and inclination.

Spitzer Space Telescope - General Observer Proposal #50089

Target of Opportunity Observations of TOADS: Finding the Dust in Super-Outburst Ejecta

Principal Investigator: Donald Hoard
Institution: IPAC, California Institute of Technology

Technical Contact: Donald Hoard, IPAC, California Institute of Technology

Co-Investigators:
David Ciardi, Michelson Science Center
Steve Howell, NOAO/WIYN Observatory

Science Category: compact objects
Observing Modes: IracMap MipsPhot IrsPeakupImage
Hours Approved: 8.7

Abstract:
Tremendous Outburst Amplitude Dwarf novae (TOADs) consist of a white dwarf primary star and an extremely low mass main sequence or brown dwarf-like secondary star. The latter fills its Roche lobe and transfers matter to the white dwarf through the inner Lagrange point into an accretion disk. TOADs undergo non-thermonuclear (i.e., disk instability) super-outbursts on timescales of decades. During the decline from super-outburst peak they display a characteristic dip in light curves at visible wavelengths, reminiscent of what is observed in slow classical (i.e., thermonuclear runaway) novae. In classical novae, the visible light dip is attributed to the formation of dust in the nova ejecta but, until now, the cause of the dip in TOAD light curves has remained unclear. In 2004, a previously unknown TOAD was discovered as it went into super-outburst, and our team was granted a Spitzer DDT program with which we have detected the likely formation of dust in the outburst ejecta. We now propose a Target of Opportunity program with Spitzer to observe an additional super-outbursting TOAD, in order to address the following questions: 1) Do all TOADs produce dust during their outbursts?; 2) What is the timescale for dust formation and dissipation?; 3) How much dust is produced during a super-outburst?; and 4) How does the dust production scale with the outburst amplitude? Spitzer is uniquely capable of detecting and characterizing the dust formed in the ejecta during super-outbursts and fundamentally changing the understanding of TOADs, their super-outbursts, and their contribution to the recycling of the interstellar medium.

Spitzer Space Telescope - Archive Research Proposal #50767

A comprehensive study of low-mass X-ray binaries in the Spitzer archive

Principal Investigator: Jeroen Homan
Institution: Massachusetts Institute of Technology

Technical Contact: Jeroen Homan, Massachusetts Institute of Technology

Co-Investigators:
Simone Migliari, UCSD
David Russell, University of Amsterdam
Rob Fender, University of Southampton
Peter Jonker, SRON, The Netherlands
Walter Lewin, MIT

Science Category: compact objects
Dollars Approved: 75000.0

Abstract:
We propose a systematic study of all observations of black hole and neutron star low-mass X-ray binaries (LMXBs) in the Spitzer archive. At least 125 unique LMXBs have now been observed with Spitzer, many as part of large Legacy surveys of the Galactic plane and bulge. This LMXB archive has remained largely unexplored. The proposed archival study builds on our recent analyses of the near-infrared and optical properties of LMXBs. With the Spitzer observations we will be able to constrain the dominant mid-infrared processes in various types of LMXBs as a function of X-ray spectral state. In particular we will focus on the properties of compact jets, with unique constrains on the power of jet outflows coming from mid-infrared data. The Spitzer mid-infrared data will be combined with our large archive of radio, near-infrared, optical, and X-ray data.

Spitzer Space Telescope - General Observer Proposal #40361

Dust disks or cyclotron emission? Why are magnetic CVs so bright in the mid-IR?

Principal Investigator: Steve Howell
Institution: WIYN Observatory

Technical Contact: Steve Howell, WIYN Observatory

Co-Investigators:
Donald Hoard, Spitzer Science Center
Carolyn Brinkworth, Spitzer Science Center

Science Category: compact objects
Observing Modes: IracMap IrsPeakupImage
Hours Approved: 3.5

Abstract:
In the first three years of operation, the Spitzer Space Telescope has discovered what are taken to be circumbinary dust disks surrounding interacting binaries of the cataclysmic variable and low-mass X-ray binary type. If true, there would be serious consequences for our current understanding of close binary evolution. However, recent detailed modeling of the observed mid-IR excess in these systems (e.g., Howell et al. 2006; Brinkworth et al. 2007) can not fully reproduce the mid-IR observations using only a dust disk. The systems observed to date have a commonality: the primary star in each (whether a white dwarf or a neutron star) is highly magnetic, having a field strength of 13MG or larger. One solution that can fit the observed IRAC fluxes is to invoke a continuum contribution from cyclotron radiation. Current models of cyclotron emission have yet to be tested at mid-IR wavelengths, and there are no predictions of what we should expect. We propose herein to search for the presence of mid-IR magnetically produced continuum radiation and thereby determine the cause of the observed mid-IR flux excesses. Additionally, we will provide the first test of the nature of cyclotron in the Spitzer wavelength regime.

Spitzer Space Telescope - General Observer Proposal #30208

Resolving Mysteries: Ultra-Cool White Dwarfs and the Age of the Galaxy

Principal Investigator: Mukremin Kilic
Institution: University of Texas at Austin

Technical Contact: Mukremin Kilic, University of Texas at Austin

Co-Investigators:
Ted von Hippel, University of Texas
Marc Kuchner, NASA Goddard Space Flight Center
William Reach, Spitzer Science Center
Adam Burrows, University of Arizona
Don Winget, University of Texas

Science Category: compact objects
Observing Modes: IracMap IrsStare
Hours Approved: 19.3

Abstract:
We performed a Spitzer/IRAC survey of 18 nearby cool white dwarfs in Cycle 1 and 2 in order to explore their flux distributions in the mid-infrared. Surprisingly, we discovered significant flux deficits in Spitzer observations of five hydrogen-rich white dwarfs cooler than 6000 K. These mid-infrared flux deficits are not predicted by state-of-the-art white dwarf models including current treatments of collision induced absorption due to molecular hydrogen. This newly discovered problem in white dwarf atmospheres prevents us from inferring the ages of the Galactic disk and halo to better than 20 percent. We propose to extend our survey to the coolest/oldest white dwarfs in the Galaxy to develop our understanding of ultra-cool white dwarf atmospheres and help us place better constraints on the age of the Galaxy. We propose to obtain IRAC photometry of 52 cool white dwarfs with ages ranging from 3 to ~10 billion years. We also propose for IRS follow-up spectroscopy of the most compelling and brightest two objects that show signs of significant mid-infrared flux deficits.

Spitzer Space Telescope - General Observer Proposal #2313

Survey for Planets and Exozodiacal Dust Around White Dwarfs

Principal Investigator: Marc Kuchner
Institution: Princeton University

Technical Contact: Marc Kuchner, Princeton University

Co-Investigators:
Adam Burrows, University of Arizona
William Reach, IPAC
Ted von Hippel, University of Texas
Donald Winget, University of Texas

Science Category: compact objects
Observing Modes: IracMap IrsStare MipsPhot
Hours Approved: 15.8

Abstract:
We propose a survey of 134 infrared-bright white dwarfs (WDs) to study their spectral energy distributions and to look for excess emission from orbiting dust and faint companions. This survey will be sensitive to planets and brown dwarfs down to effective temperatures of 300K or less and to dust clouds with 1% of the optical depth of the cloud around G 29-38, the only WD known to host a dust disk.

Spitzer Space Telescope - General Observer Proposal #20224

Probing accreting neutron star jets with infrared observations of ultracompact binaries

Principal Investigator: Tom Maccarone
Institution: University of Southampton

Technical Contact: Tom Maccarone, University of Southampton

Co-Investigators:
Simone Migliari, University of Amsterdam
Elena Gallo, University of amsterdam
Gijs Nelemans, Radboud Universiteit Nijmegen
John Tomsick, University of California San Diego
Rob Fender, University of Southampton

Science Category: compact objects
Observing Modes: IracMap
Hours Approved: 1.7

Abstract:
We propose 1.7 hours of Spitzer observations to obtain flux measurements of six ultracompact X-ray binaries. Spitzer is uniquely suited to this task, as it can obtain substantially better flux limits than radio observatories for flat spectrum synchrotron sources, and will suffer much less from contamination of the synchrotron emission by the accretion disk's emission than ground-based optical and infrared facilities. Using the ultracompact systems, which are known to have short orbital periods and hence very small accretion disks assures that even down to faint flux levels, the emission will still have to come from an emission region substantially larger than the binary separation (i.e. a jet). Since the black hole accretors which are well studied show flat optically thick synchrotron spectra which extend into the optical, we are optimistic that sensitive infrared observations have the potential also to make good measurements of accreting neutron stars' jets. The systems we propose to observe are all neutron star accretors, which, as a class, have much lower jet fluxes than black hole accretors. This reduced emission has hampered past efforts aimed at measuring quantitative relationships between the accretion disk emission, measured in the X-rays and the jet emission, usually measured in the radio. The survey we propose represents a pilot program to see if we can do better in the infrared than we have done in the past in the radio. If we are successful in detecting infrared jet emission from some or all of these sources, we will have proven that these systems have relatively flat spectra from radio through infrared, and will have the first epoch of a monitoring program that will help us to understand whether the neutron star accretors follow the same quantiative relationships between X-ray (i.e. accretion disk) and jet emission as do the black holes. This work would thus help us to understand the connection between the nature of the compact object and the production of relativistic jets.

Spitzer Space Telescope - Directors Discretionary Time Proposal #257

Spitzer Measurements of Pulsar Infrared Light Curves

Principal Investigator: William Mahoney
Institution: California Institute of Technology

Technical Contact: William Mahoney, California Institute of Technology

Science Category: compact objects
Observing Modes: IracMap
Hours Approved: 3.4

Abstract:
Spitzer measurements of pulsar infrared light curves is a capability that, while quite feasible, has yet to be exploited by any approved program. To explore this techniqye we propose to use the rapid readout capability of the IRAC subarray mode to obtain long time histories of the emission form three Anomalous X-Ray Pulsars (AXPs) know to have near-infrared counterparts. The light curves will be obtained by first extracting the source fluxes at the known pulsar position and then phase-folding them at the pulsar period. While these observations are expected to significantly expand our understanding of the emission mechanisms of AXPs, the primary objective is to demonstrate the Spitzer capability of measuring pulsar light curves with potential applications to the study of periodic and quasi-periodic emission from other AXPs, Soft Gamma Repeaters (SGRs), isolated radio and X-ray pulsars, and perhaps accreting binary pulsars.

Spitzer Space Telescope - General Observer Proposal #30803

Multi-wavelength observations of compact jets in a neutron star X-ray binary

Principal Investigator: Simone Migliari
Institution: University of California San Diego

Technical Contact: Simone Migliari, University of California San Diego

Co-Investigators:
John Tomsick, UCSD
Elena Gallo, UCSB
Thomas Maccarone, University of Southampton
Rob Fender, University of Southampton
Gijs Nelemans, University of Nijmegen
Peter Jonker, SRON, Utrecht

Science Category: compact objects
Observing Modes: IracMap MipsPhot
Hours Approved: 1.5

Abstract:
Our cycle-2 Spitzer IRAC observations revealed the first spectral evidence for compact jets in low-luminosity neutron star (NS) X-ray binary, and furthermore, the optically thin ('break') part of its synchrotron spectrum in 4U~0614+091. As a follow-up of this major result, we ask for simultaneous IRAC and VLA observations of 4U~0614+091 together with quasi-simultaneous MIPS observations at 24um. These multi-wavelength coverage, will give us the first complete broadband spectrum of a compact jet in a low-luminosity NS system. Low-luminosity NSs are important especially because they are the best candidate for a direct comparison of the disc/jet properties in BHs. We will measure observable jet parameters never measured before together in a NS system (e.g. the spectral index in the optically thick and optically thin part of the spectrum, and the break frequency), we will have a precise estimate of the power in the jet and, together with available simultaneous X-rays observations, we will assess the efficiency of the jet production, estimating the fraction of the accreted power that is channeled into the jet.

Spitzer Space Telescope - General Observer Proposal #20702

Investigation of Mid-infrared Dust Emission of Highly Obscured X-ray Binaries

Principal Investigator: Dae-Sik Moon
Institution: California Institute of Technology

Technical Contact: Dae-Sik Moon, California Institute of Technology

Co-Investigators:
David Kaplan, Massachusetts Institute of Technology
William Reach, Spitzer Science Center
Fiona Harrison, California Institute of Technology

Science Category: compact objects
Observing Modes: IrsStare
Hours Approved: 2.8

Abstract:
We propose to conduct Spitzer/IRS observations of four highly obscured X-ray binaries with presumed supergiant O/B companions: IGR J16318-4848, XTE J0421+560, GX 301-2, and X1908+075. These sources are distinguished by the large amounts of hydrogen along the lines-of-sight: N_H > 10^23 cm^-2 (or A_V > 100). In particular, the hydrogen column density towards IGR J16318-4848, a new source recently discovered by the INTEGRAL hard X-ray satellite, reaches N_H ~ 2 x 10^24 cm^-2, one of the highest known among all X-ray sources. IGR J16318-4848 represents the first and brightest of a growing number of similar sources discovered by INTEGRAL, but as yet their natures are not clear. Using archival near- and mid-infrared data we have found that three of the four sources above (all but X1908+075) have significant amounts of excess mid-infrared emission. The excess is most likely caused by warm dust accreting onto a compact object, which is quite unique for X-ray binaries and may prove to be the cause of the extremely high column densities. The primary purpose of the proposed observations is to identify and investigate the (potential) dust emission using IRS mid-infrared spectra which can help understand: [1] the origin of the extreme obscuration of the X-ray binaries, [2] the evolutionary track of high-mass X-ray binaries with circumstellar dust shell, [3] the properties of dust emission under strong X-ray illumination, and [4] hopefully unravel the nature of the new INTEGRAL hard X-ray sources.

Spitzer Space Telescope - General Observer Proposal #3289

Searching for Circumbinary Disks around Low-Mass X-ray Binaries

Principal Investigator: Michael Muno
Institution: University of California, Los Angeles

Technical Contact: Michael Muno, University of California, Los Angeles

Co-Investigators:
Michael Jura, University of California, Los Angeles

Science Category: compact objects
Observing Modes: IracMap MipsPhot
Hours Approved: 3.5

Abstract:
We propose to search in the mid-infrared for circumbinary disks around quiescent low-mass X-ray binaries (LMXBs) containing black holes and neutron stars. Circumbinary disks have been inferred to exist around similar binaries containing accreting white dwarfs, and could be the main mechanism by which angular momentum is extracted from their orbits. If such disks exist around LMXBs, they could be the site in which planetary systems like that around the isolated millisecond pulsar PSR 1257+12 formed. We show that a circumbinary disk could readily be detected at 8 and 24 um with IRAC and MIPS, and propose a series of observations (of total duration 3.5 h) to search for them around four of the nearest quiescent LMXBs.

Spitzer Space Telescope - General Observer Proposal #3696

Mid-IR observations of young pulsars

Principal Investigator: Divas Sanwal
Institution: Pennsylvania State University

Technical Contact: Divas Sanwal, Pennsylvania State University

Co-Investigators:
George Pavlov, Penn State University
Oleg Kargaltsev, Penn State University

Science Category: compact objects
Observing Modes: IracMap
Hours Approved: 5.3

Abstract:
PSR B0656+14 and the Vela pulsar are the brightest intermediate-age pulsars which have been extensively studied in both X-rays and NIR/optical/UV. The spectra of these pulsars exhibit both the thermal component, emitted from the hot neutron star surface, and the non-thermal component, originating in the NS magnetosphere. In addition, the wide-band optical/NIR photometry of PSR B0656+14 has provided evidence for spectral feature(s) between 0.3 and 1.5 microns. However, the level and the slope of the non-thermal continuum has not yet been accurately measured. The proposed observations will significantly extend the spectral coverage toward longer wavelengths and provide the measurement of the non-thermal continuum with a much higher accuracy. This will allow us to discriminate between different magnetosphere emission models, further constrain the properties of thermal emission, and asses the significance of the spectral features. The mid-IR sensitivity of Spitzer opens an opportunity to study this yet unexplored part of pulsar spectra. We will also obtain the deepest IR image of the Vela pulsar field and possibly detect emission from the pulsar-wind nebula that so far has been studied only in the radio and X-rays.

Spitzer Space Telescope - Directors Discretionary Time Proposal #50345

A Search for Debris Disks around Variable Pulsars

Principal Investigator: Ryan Shannon
Institution: Cornell University

Technical Contact: Ryan Shannon, Cornell University

Co-Investigators:
James Cordes, Cornell University
Joseph Lazio, Naval Research Laboratory
Andrew Lyne, University of Manchester
Michael Kramer, University of Manchester

Science Category: compact objects
Observing Modes: IracMap
Hours Approved: 6.8

Abstract:
After a supernova explosion, a modest amount of material is likely to fall back into a disk surrounding the resultant neutron star. The material will aggregate into rocky debris and the disk will be stable for the entire lifetime of a canonical (non-recycled) radio pulsar. We propose a search for debris disks around older canonical pulsars. We have developed a model that unifies the different classes of radio variability observed in many older pulsars. Rocky material migrates inwards from a debris disk and is ablated inside the pulsar magnetosphere. This material alters the electrodynamics in the magnetosphere and can cause the observed quiescent and bursting states observed in nulling pulsars, intermittent pulsars, and rotating radio transients. With this model in mind, we select three nulling pulsars and one intermittent pulsar as the best candidates to host debris disks detectable by the Spitzer IRAC camera. In addition to the potential of detecting debris disks in this new environment, we will be able to test our model of pulsar variability. Disk luminosities and upper limits will set debris migration rates and hence the role debris can play in altering pulsar emission. Previous searches for debris around pulsars have focused on searching for fallback disks around very young neutron stars; young, energetic pulsars; and old recycled millisecond pulsars, for which debris likely forms from a different mechanism. By observing older canonical pulsars, we complete a survey of all classes of neutron stars and can assess presence of debris disk as a function of pulsar type.

Spitzer Space Telescope - General Observer Proposal #20301

Compact Jets from Galactic Black Holes

Principal Investigator: John Tomsick
Institution: University of California, San Diego

Technical Contact: John Tomsick, University of California, San Diego

Co-Investigators:
Charles Bailyn, Yale University
Michelle Buxton, Yale University
Stephane Corbel, Universite Paris VII and CE Saclay
Rob Fender, University of Southampton
Mario Jimenez-Garate, MIT
Philip Kaaret, University of Iowa
Emrah Kalemci, University of California, Berkeley
Sera Markoff, MIT

Science Category: compact objects
Observing Modes: IracMap MipsPhot
Hours Approved: 7.0

Abstract:
While Galactic and extra-galactic accreting black holes can emit powerful, collimated jets, the mechanism for jet production as well as many of the basic properties of jets remain unknown. An important development in the study of Galactic black hole X-ray binaries is the discovery that these systems produce ''compact'' jets that remain steady for time periods of weeks with powers that are significant when compared to the overall energetics of the system. Compact jet spectra rise with frequency in the radio band, and, although they have not been previously studied in the far-infrared (FIR), spectral fits to radio and near-infrared (NIR) fluxes suggest that they are often brightest in the FIR. We propose a continuation of our approved cycle 1 Target of Opportunity (TOO) Spitzer program to observe black holes at times when they are producing compact jets. We are asking for two TOO triggers, and our program, which uses all three Spitzer instruments, requires nearly 7 hours of mission time per trigger (including all overheads). When combined with simultaneous or near-simultaneous X-ray and ground-based observations in the radio, near-IR, and optical, our program will provide unprecedented multi-wavelength coverage of the compact jet phenomenon in these systems. We plan to use the multi-wavelength spectra along with a theoretical model that accounts for emission from the accretion disk as well as the jet to distinguish between possible emission mechanisms and to constrain the physical properties of the jet.

Spitzer Space Telescope - General Observer Proposal #30702

Compact Jets from Galactic Black Holes

Principal Investigator: John Tomsick
Institution: University of California, San Diego

Technical Contact: John Tomsick, University of California, San Diego

Co-Investigators:
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Charles Bailyn, Yale University
Michelle Buxton, Columbia University
Stephane Corbel, Universite Paris VII and CE Saclay
Rob Fender, University of Southampton
Philip Kaaret, University of Iowa
Emrah Kalemci, Sabanci University
Sera Markoff, University of Amsterdam

Science Category: compact objects
Observing Modes: IracMap IrsPeakupImage MipsPhot
Hours Approved: 13.9

Abstract:
While Galactic and extra-galactic accreting black holes can emit powerful, collimated jets, the mechanism for jet production as well as many of the basic properties of jets remain unknown. An important development in the study of Galactic black hole X-ray binaries is the discovery that these systems produce ''compact'' jets that remain steady for time periods of weeks with powers that are significant when compared to the overall energetics of the system. Compact jet spectra rise with frequency in the radio band, and, although they have not been well-studied in the far-infrared (FIR), spectral fits to radio and near-infrared (NIR) fluxes suggest that they are often brightest in the FIR. We propose a continuation of our previously approved Target of Opportunity (TOO) Spitzer program to observe black holes at times when they are producing compact jets. We are asking for two TOO triggers, and our program, which uses all three Spitzer instruments, requires nearly 7 hours of mission time per trigger (including all overheads). When combined with simultaneous or near-simultaneous X-ray and ground-based observations in the radio, near-IR, and optical, our program will provide unprecedented multi-wavelength coverage of the compact jet phenomenon in these systems. We plan to use the multi-wavelength spectra along with a theoretical model that accounts for emission from the accretion disk as well as the jet to distinguish between possible emission mechanisms and to constrain the physical properties of the jet.

Spitzer Space Telescope - General Observer Proposal #3246

Compact Jets from Galactic Black Holes

Principal Investigator: John Tomsick
Institution: University of California, San Diego

Technical Contact: John Tomsick, University of California, San Diego

Co-Investigators:
Charles Bailyn, Yale University
Michelle Buxton, Yale Univerisy
Stephane Corbel, Universite Paris VII and CE Saclay
Rob Fender, University of Amsterdam
Mario Jimenez-Garate, MIT
Philip Kaaret, Harvard-Smithsonian CfA
Emrah Kalemci, University of California, Berkeley
Sera Markoff, MIT

Science Category: compact objects
Observing Modes: MipsPhot
Hours Approved: 12.0

Abstract:
While Galactic and extra-galactic accreting black holes can emit powerful, collimated jets, the mechanism for jet production as well as many of the basic properties of jets remain unknown. A recent development in the study of Galactic black hole X-ray binaries is the discovery that these systems produce ''compact'' jets that remain steady for time periods of weeks with powers that are significant when compared to the overall energetics of the system. Compact jet spectra rise with frequency in the radio band, and, although they have not been previously studied in the far-infrared (FIR), spectral fits to radio and near-infrared (NIR) fluxes suggest that they are often brightest in the FIR. We propose Target of Opportunity observations using the MIPS instrument on-board Spitzer for black holes at times when they are producing compact jets. We are requesting for time to observe two targets, and our program requires 6 hours per target (including all overheads). When combined with simultaneous or near-simultaneous X-ray and ground-based observations in the radio, near-IR, and optical, our program will provide unprecedented multi-wavelength coverage of the compact jet phenomenon in these systems. We plan to use the multi-wavelength spectra along with a theoretical model that accounts for emission from the accretion disk as well as the jet to distinguish between possible emission mechanisms and to constrain the physical properties of the jet.

Spitzer Space Telescope - Archive Research Proposal #20368

Shedding New Light on the Stellar Graveyard: Compact Objects in the Mid-IR

Principal Investigator: Stefanie Wachter
Institution: California Institute of Technology

Technical Contact: Stefanie Wachter, California Institute of Technology

Co-Investigators:
Donald Hoard, SSC/ Caltech
Reba Bandyopadhyay, Oxford University
Carolyn Brinkworth, University of Southampton / SSC
David Ciardi, MSC / Caltech
Cynthia Froning, University of Colorado
Steve Howell, NOAO
Sera Markoff, MIT
Paula Szkody, University of Washington
Gerard van Belle, MSC / Caltech

Science Category: compact objects
Dollars Approved: 32321.0

Abstract:
We propose a systematic Spitzer archival study of the mid-IR properties of compact objects, both isolated and in binary systems, i.e. white dwarfs, X-ray binaries, cataclysmic variables, and magnetars. Most of these sources are too faint at mid-IR wavelengths to be observable from the ground, so this study will provide the very first comprehensive look at the mid-IR emission of these objects. The particular goals of our project are to establish the mid-IR spectral energy distribution, to search for the signatures of jets, circumbinary disks, low mass or planetary companions and debris disks, and to study the local environment of these sources.

Spitzer Space Telescope - General Observer Proposal #20462

Jets in Neutron Star X-ray Binaries: A First Look at Sco X-1 in the Mid -Infrared

Principal Investigator: Stefanie Wachter
Institution: California Institute of Technology

Technical Contact: Stefanie Wachter, California Institute of Technology

Co-Investigators:
Sera Markoff, MIT
Reba Bandyopadhyay, Oxford University

Science Category: compact objects
Observing Modes: IracMap IrsPeakupImage MipsPhot
Hours Approved: 0.9

Abstract:
Jets are a ubiquitous feature in many different astrophysical objects. Among the best systems to study jet properties and formation are Galactic X-ray binaries (XRBs), systems composed of a neutron star or black hole accreting matter from a 'normal' star mass donor. The past few years have seen significant advances in the characterization of jets in XRBs, particularly through modeling of the broad band spectral distribution from the radio to the X-rays. Unfortunately, with few exceptions, the mid-infrared measurements which are crucial in establishing the connection between the near-IR and radio emission have not been performed owing to the technical difficulty in undertaking such observations from the ground. The Spitzer Space Telescope provides the unique capabilities to fill this gap. We propose here to study the mid-IR emission of Sco X-1, the prototypical XRB, in order to constrain the contribution of jet radiation to the broadband spectrum from radio to X-rays, to explore any differences in the spectra of jets between black hole and neutron star systems, and to provide a mid-IR calibrator for XRBs in general.

Spitzer Space Telescope - General Observer Proposal #20747

What makes a Neutron Star a Magnetar?

Principal Investigator: Stefanie Wachter
Institution: California Institute of Technology

Technical Contact: Stefanie Wachter, California Institute of Technology

Co-Investigators:
Chryssa Kouveliotou, NASA/MSFC
Don Figer, STScI
Donald Hoard, SSC
Sandeep Patel, NSSTC/USRA
Peter Woods, NSSTC/USRA

Science Category: compact objects
Observing Modes: IracMap IrsPeakupImage MipsScan
Hours Approved: 17.0

Abstract:
There exists a small class of high-energy transients that are thought to be "magnetars", i.e. neutron stars with ultrahigh magnetic fields. At the same time, we now also know of a small sample of radio pulsars with magnetic field strengths approaching or overlapping those of the magnetar candidates, but do not exhibit the same type of high energy phenomena. This raises the question why some neutron stars are "normal" radio pulsars, while others are X-ray and gamma-ray emitting magnetars. The magnetic field strength alone cannot be the sole factor in determining whether a neutron star exhibits magnetar characteristics. One suggestion is that magnetars originate from more massive progenitors than radio pulsars, so that the environment in which these neutron stars are formed plays a critical role. Embedded clusters of massive stars have been detected around some of the magnetar candidates in the near-IR. We propose a uniform study of the environment of magnetars with Spitzer, with the goals of searching for additional embedded clusters, characterizing the mid-IR SEDs of their stellar contents and searching for evidence of mass loss events from the massive star progenitors.

Spitzer Space Telescope - General Observer Proposal #50101

A Magnetar Mystery: The Nature of the Ring around SGR 1900+14

Principal Investigator: Stefanie Wachter
Institution: California Institute of Technology

Technical Contact: Stefanie Wachter, California Institute of Technology

Co-Investigators:
Chryssa Kouveliotou, NASA/MSFC
Vikram Dwarkadas, University of Chicago
Sandeep Patel, Optical Sciences Corporation

Science Category: compact objects
Observing Modes: IrsStare
Hours Approved: 3.5

Abstract:
Soft Gamma repeaters (SGRs) and anomalous X-ray pulsars are thought to be "magnetars", isolated young neutron stars that are powered by the decay of their ultrahigh magnetic fields. At the same time, we now also know of a small sample of radio pulsars with magnetic field strengths approaching or overlapping those of the magnetar candidates, that do not exhibit the same type of high energy phenomena. This raises the question why some neutron stars are "normal" radio pulsars, while others are X-ray and gamma-ray emitting magnetars. We have discovered a ring of emission around SGR 1900+14 with Spitzer at 16 and 24 micron which might provide clues to the nature of the progenitor and the formation of the SGR. However, the ring is not detected at optical, near-IR, radio, or X-ray wavelengths and is difficult to interpret within the current framework of stellar mass loss and supernova remnant evolution. We propose Spitzer IRS spectroscopic follow-up observations to determine the physical properties of the ring material and possibly unveil the nature of the progenitor of the SGR.

Spitzer Space Telescope - Directors Discretionary Time Proposal #298

Detecting the mid-IR counterpart to the anomalous X-ray pulsar 1E 1048.1 -5937 during its X-ray flare

Principal Investigator: Zhongxiang Wang
Institution: McGill U.

Technical Contact: Zhongxiang Wang, McGill U.

Co-Investigators:
Victoria Kaspi, McGill U.

Science Category: compact objects
Observing Modes: IracMap
Hours Approved: 1.1

Abstract:
The anomalous X-ray pulsar (AXP) 1E 1048.1-5937 is one of a dozen sources believed to be magnetars---young neutron stars with extremely strong magnetic fields (~10^14 G). On 2007 April 3, a sudden spin-up (glitch) and X-ray flux enhancement event in the AXP was detected in our RXTE X-ray monitoring observations of the source. Our follow-up Magellan ToO and ESO/VLT DDT observations find that the source's optical/near-IR counterpart has brightened by more than 1.3 mag (compared to the previous measurements in 2003). The current X-ray and near-IR fluxes of the AXP both predict detectable mid-IR emission from the source by Spitzer. Therefore, we propose a Spitzer/IRAC imaging observation of the source, seeking to detect the source in the mid-IR and to probe if there is a similar degree of brightening in the mid-IR. If detected, this would allow us to construct the second optical/IR spectral energy distribution for magnetars, thus helping understand the physical origin for the still mysterious optical and IR emission in magnetars.

Spitzer Space Telescope - General Observer Proposal #50756

First Mid-Infrared Detection of A Bow Shock Structure Around A Pulsar

Principal Investigator: Zhongxiang Wang
Institution: McGill University

Technical Contact: Zhongxiang Wang, McGill University

Co-Investigators:
Victoria Kaspi, McGill University
Patrick Slane, Harvard
David Kaplan, MIT

Science Category: compact objects
Observing Modes: IrsStare MipsPhot
Hours Approved: 2.0

Abstract:
In our on-going Spitzer IRAC survey of 7 relatively young pulsars, a bow shock structure has been detected at 8.0 microns around pulsar J1549-4848. The 8.0 micron emission is likely thermal, arising from the shocked dust in the interstellar medium (ISM). This detection represents a type of pulsar wind interaction with the ISM that has never before been seen, suggesting a new window for studying pulsars and their interactions with the ISM. In order to understand the detected shock, we propose Spitzer MIPS imaging and IRS spectroscopic observations of the shock region. We request MIPS 24 and 70 micron imaging of the bow shock to determine the temperature and mass of the shocked dust. We also request a 7.4-14 micron spectrum of the shock region, seeking to study the shocked ISM by searching for certain line features. The continuum spectrum will provide flux measurements for determining the dust temperature. These mid-infrared observations can only be made with Spitzer's unique capabilities.

Spitzer Space Telescope - General Observer Proposal #20567

Searching for Dying Solar Systems: A Complete Survey of Nearby, Young White Dwarfs

Principal Investigator: Hans Zinnecker
Institution: Astrophysikalisches Institut Potsdam

Technical Contact: Hans Zinnecker, Astrophysikalisches Institut Potsdam

Co-Investigators:
Matt Burleigh, University of Leicester (UK)
Emma Hogan, University of Leicester (UK)
Stefanie Wachter, Spitzer Science Center
Donald Hoard, Spitzer Science Center
Carolyn Brinkworth, U. of Southampton/Spitzer Science Center
Harold Yorke, NASA-JPL
Fraser Clarke, University of Oxford (UK)
Susanne Friedrich, MPE (Germany)
Wolfgang Brandner, MPIA (Germany)

Science Category: compact objects
Observing Modes: IracMap
Hours Approved: 3.5

Abstract:
We propose to extend and complement our established ground-based and HST-based near-IR surveys for giant planetary companions to nearby young white dwarfs to the mid-infrared, by searching for photometric excesses with IRAC on Spitzer. These observations will allow us to stretch our current detection limits to lower masses (5 Jupiter masses or less). We have carefully selected a complete sample of 40 young (<2.5 Gyr), nearby (<25 pc) white dwarfs for this survey. Of these, nearly 30 have been approved for observations with Spitzer in various Cycle 1 programs; this proposal seeks IRAC observations for the remainder. These are ideal targets (best possible brightness ratio) against which one can detect direct radiation from giant self-luminous planets, and the mid-IR (IRAC) regime is the most promising wavelength range for these cool (300-500 K) companions. As white dwarfs are the descendants of main sequence stars more massive than the Sun, our survey will cast light on the frequency of giant planets around intermediate mass stars that survived post-main sequence evolution. As a fringe benefit, we may also discover several cool debris disks around white dwarfs which can be discriminated against planets by their red colors across the IRAC bands. Our team has the expertise in white dwarf photospheres, in brown dwarf and exo-planet astrophysics, and in mid-IR astronomy to carry this project to success.

Spitzer Space Telescope - General Observer Proposal #3548

Identifying and Studying Circumstellar Disks Around Nearby Metal-Rich White Dwarfs

Principal Investigator: Ben Zuckerman
Institution: University of California, Los Angeles

Technical Contact: Ben Zuckerman, University of California, Los Angeles

Co-Investigators:
Eric Becklin, University of California, Los Angeles
Jay Farihi, University of California, Los Angeles

Science Category: compact objects
Observing Modes: IracMap
Hours Approved: 8.1

Abstract:
Observational evidence that pertains to the existence of extrasolar analogs of the asteroid belt and of the Oort comet cloud is very scarce. Because of the very low mass of white dwarf photospheres, the accretion of cometary or asteroidal material can have observational consequences. We are proposing to use IRAC and IRS to shed light on the prevalence of asteroid belts and Oort-like comet clouds around white dwarfs and, thus, by extension, their main sequence progenitors.

Spitzer Space Telescope - General Observer Proposal #20026

Follow-up Study of Unusual White Dwarfs: Planets, Disks, and Deep 8 Micron Deficits

Principal Investigator: Ted von Hippel
Institution: University of Texas at Austin

Technical Contact: Ted von Hippel, University of Texas at Austin

Co-Investigators:
Adam Burrows, University of Arizona
Mukremin Kilic, University of Texas at Austin
Marc Kuchner, Princeton University
Fergal Mullally, University of Texas at Austin
William Reach, IPAC
Donald Winget, University of Texas at Austin

Science Category: compact objects
Observing Modes: IracMap IrsStare MipsPhot
Hours Approved: 21.1

Abstract:
We have begun a survey of 130 white dwarfs (WDs) with Spitzer to search for infrared photometric anomalies caused by faint companions and disks. We propose follow-up photometry and spectroscopy of a few interesting objects uncovered so far that show signs of either novel absorption features or of hosting planets or disks. The novel absorption features appear in the coolest white dwarfs we surveyed; using white dwarfs to derive the age of the Galaxy demands understanding them. A few warmer white dwarfs with normal photospheres display excesses at 4.5 and/or 8 microns, signposts of giant planets or dust disks, respectively. This study holds an opportunity to take the first mid-infrared spectrum of an extrasolar planet.

Spitzer Space Telescope - General Observer Proposal #3277

Dusty Evolved Stars in the Small Magellanic Cloud

Principal Investigator: Michael Egan
Institution: Air Force Research Laboratory

Technical Contact: Kathleen Kraemer, Air Force Research Laboratory

Co-Investigators:
Kathleen Kraemer, AFRL
Greg Sloan, Cornell University
Stephen Price, AFRL

Science Category: extragalactic stellar studies
Observing Modes: IrsStare
Hours Approved: 17.0

Abstract:
We propose to use the Spitzer Space Telescope to examine the spectral properties of the dust around evolved stars in the low-metallicity environment of the Small Magellanic Cloud (SMC) and determine how the dust differs from the dust produced in more metal-rich environments. Observations with the IRS will enable us to address a number of issues and predictions related to fundamentally important questions of how the chemical and optical properties of dust in low-metallicity galaxies in the distant universe differ from the Milky Way. Among the effects we expect to see are: a reduction of the relative strength of the 11.3 um SiC feature and the 26-30 um MgS feature in spectra from carbon stars; the first detection of Fe-rich crystalline silicates in a circumstellar environment by looking for shifts in the positions of crystalline silicate features in OH/IR stars; an enhancement in the strength of the 13 um feature and related dust features at 20 and 28 um in spectra produced in optically thin oxygen-rich dust shells. These observations will also help refine the use of JHK and mid-infrared photometry to determine the chemistry of circumstellar dust shells in extragalactic environments. Our increased confidence from IRS spectra in spectral/chemical identifications based on photometric colors will give the astronomical community a powerful tool to probe the properties of low-metallicity galaxies in the early universe with the Spitzer Space Telescope.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #30180

An Enigmatic Source Towards The LMC

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Brian Patten, Harvard-Smithsonian

Co-Investigators:
Brian Patten, Smithsonian Astrophysical Observatory
Joseph Hora, Smithsonian Astrophysical Observatory
Matthew Ashby, Smithsonian Astrophysical Observatory
Nitya Kallivayalil, Harvard University
Pauline Barmby, Smithsonian Astrophysical Observatory

Science Category: extragalactic stellar studies
Observing Modes: IrsStare
Hours Approved: 1.0

Abstract:
We are proposing to invest a small amount of Spitzer/IRS time to acquire a low resolution spectrum from 5.2-38 microns as part of a program to ascertain the physical nature of a 24-micron bright/IRAC faint enigmatic object seen in the direction of the LMC. This object just discovered while investigating the infrared SED of gravitational microlensing event MACHO-LMC-4, as a part of GTO program PID 118 "Macho Search". We serendipitously noted an object in both the IRAC and MIPS fields-of-view that was very bright at 24 microns (9 mJy), but had very low flux levels in all IRAC bandpasses (0.93 mJy at 8 microns). Because of the shape of the broadband SED as observed by IRAC and MIPS, we favor two basic possibilities as being the most likely explanation for the nature of his object: (1) A z~2 starburst galaxy, where the strong 24 micron emission is produced by 8 micron rest-frame PAH emission redshifted into the MIPS 24 micron bandpass or (2) A dust enshrouded luminous blue variable (LBV) in a pre-planetary nebula (pre-PN) evolutionary state. We will use the IRS in standard staring mode to acquire spectra with both low resolution modules in the range of 5.2 - 38 microns. A IRS low-resolution spectrum will reveal a more detailed picture of the shape of its SED. We estimate that no more than 1 hour will be required to obtain spectra with sufficient signal-to-noise to determine whether this object is a distant starburst galaxy (via a PAH emission peak) or a more nearby pre-PN LBV (a rising continuum that flattens off towards the mid-IR). The proposed observation represents the first stage of investigating nature of this object.

Spitzer Space Telescope - General Observer Proposal #40347

Spitzer Observations of Eclipsing Binaries with Cepheid Components: a Key to the Extragalactic Distance Scale

Principal Investigator: Edward Guinan
Institution: Villanova University

Technical Contact: Edward Guinan, Villanova University

Co-Investigators:
Scott Engle, Villanova University
Edward Fitzpatrick, Villanova University
Ignasi Ribas, IEEC, Spain

Science Category: extragalactic stellar studies
Observing Modes: IracMap
Hours Approved: 0.3

Abstract:
We propose SST observations of two rare and critically important LMC eclipsing binaries (EBs) containing Cepheids: a 17.3-mag EB with P(orb) = 801-d, which contains a classical 2.03-d Cepheid, and a 14.5-mag EB with P(orb) = 397.25-d containing a 4.98-d Cepheid. These systems have light and radial velocity curves, as well as HST/STIS spectra. From these data we have determined their preliminary orbital and physical properties such as stellar masses, radii, Teffs, luminosities and distances. The astrophysical and cosmological consequences of finding a Cepheid in an eclipsing binary are considerable. Such systems hold the key to simultaneously determining the zero-point of the Cepheid P-L law & the LMC distance as well as providing tests of the Baade-Wesselink parallax method. The requested SST/IRAC observations will significantly reduce (possibly eliminate) the largest source of uncertainty in the present solutions - the determination of the reddening and interstellar absorptions in the line-of-sight to the two targets. Combining the proposed SST photometry with our STIS spectrophotometry will permit the unequivocal determination of the interstellar reddening law (i.e., the value of "R" in Av = R x E(B-V)) and A(lambda) for each system as well as providing superior determinations of the stars' temperatures & distances. Because of the importance of these systems in determining a more precise LMC distance, and for calibration of the Cepheid P-L Law, we are endeavoring to minimize all known sources of observational uncertainties with SST. Due to the relative faintness of these two EBs, and the need for IR observations to reliably determine the ISM absorptions, SST is the best-suited, and possibly the only instrument, capable of achieving our science goals. The proposed brief ~21-min of SST time (when combined with existing data) offers the unprecedented opportunity to probe the LMC distance, "self-calibrate" the Cepheid P-L law, and determine directly the fundamental properties of the Cepheids themselves.

Spitzer Space Telescope - General Observer Proposal #3426

The Spitzer IRS Spectral Atlas of Infrared-Luminous Evolved Stars in the Large Magellanic Cloud

Principal Investigator: Joel Kastner
Institution: Rochester Institute of Technology

Technical Contact: Joel Kastner, Rochester Institute of Technology

Co-Investigators:
Raghvendra Sahai, JPL
Michael Egan, Air Force Rsch Lab
Bruce Hrivnak, Valparaiso University
William Forrest, University of Rochester
Adam Frank, University of Rochester
Cecilia Barnbaum, Valdosta St. University

Science Category: extragalactic stellar studies
Observing Modes: IrsStare
Hours Approved: 27.0

Abstract:
Highly evolved, mass-losing stars are the most infrared-luminous, non-transient stellar objects in the universe. Mass loss from such stars drives the chemical evolution of the universe and, ultimately, determines the infrared emission signatures of other important Spitzer sources ranging from Galactic H II regions to infrared-luminous galaxies at high redshift. We propose to obtain IRS spectra of 66 of the dustiest, most luminous post-main sequence stars in the Large Magellanic Cloud (LMC). From these data we will infer the circumstellar chemistries of the LMC's most rapidly mass-losing evolved stars, i.e., the objects that likely dominate the rate of return of nuclear-processed material to the interstellar medium of the LMC. In addition to providing new insight into the chemical enrichment of the LMC and the dependence of circumstellar chemistries on the masses and evolutionary states of red giant progenitors, a key outcome of this IRS survey will be the definitive calibration of photometric indicators of envelope chemistry. Thus, our catalog of IRS spectra of the most IR-luminous mass-losing stars in the LMC will be an indispensible tool with which to intepret near-IR and Spitzer photometry of Local Group galaxies in terms of the mass-losing evolved star populations and rates of chemical enrichment of these galaxies.

Spitzer Space Telescope - General Observer Proposal #30192

A Spitzer Survey of Selected Novae in M31

Principal Investigator: Allen Shafter
Institution: San Diego State University

Technical Contact: Karl Misselt, University of Arizona

Co-Investigators:
Karl Misselt, University of Arizona
Michael Bode, Liverpool John Moores University Astrophysics Rese

Science Category: extragalactic stellar studies
Observing Modes: IracMap IrsStare
Hours Approved: 15.3

Abstract:
We propose to observe a sample of 8 novae in the bulge and disk of M31 using IRAC and IRS as part of the first systematic extragalactic survey of novae in the infrared. The nova sample will be selected from the second year of an ongoing M31 nova patrol. The IRAC photometry will be used to search for the ~1000K thermal emission from dust grains formed in the ejecta, while the IRS data will be used to search for the prominent Ne emission lines at 7.6 and 12.8um. Observations of Galactic novae suggest that novae exhibiting prominent dust shells arise from systems containing CO white dwarfs, while those that display significant Ne emission are associated with novae harboring more massive ONeMg white dwatfs, and thus the two types of novae appear to be mutually exclusive. Stellar population models predict that nova binaries containing ONeMg white dwarfs are more common in younger stellar populations, such as the Galactic disk, but are rare in the older stellar populations found in the bulges of spirals, where CO white dwarfs should dominate. It is difficult to test this prediction in the Galaxy, since the majority of Galactic novae are consistent with an association with a disk population. However, a comparison of the IR properties of novae in M31's bulge with well-studied Galactic disk novae (and perhaps with M31 disk novae), will provide an important constraint on the properties of novae from differing stellar populations.

Spitzer Space Telescope - Guaranteed Time Observer Proposal #50147

SH spectra of unusual spectral features in the Magellanic Clouds

Principal Investigator: Greg Sloan
Institution: Cornell University

Technical Contact: Greg Sloan, Cornell University

Co-Investigators:
Kathleen E. Kraemer, Air Force Research Lab., Hanscom AFB
Jeronimo Bernard-Salas, Cornell University

Science Category: extragalactic stellar studies
Observing Modes: IrsStare
Hours Approved: 6.0

Abstract:
We propose to use the Short-High module on the IRS to observe five evolved objects in the Magellanic Clouds with unusual spectral features in the 13-17 um spectral region revealed by low-resolution IRS observations. This spectral region is opaque from ground-based and airborne observatories, so the next opportunity to study these sources will come only with the launch of the next infrared space telescope. One object is in transistion from the asymptotic giant branch to a planetary nebula and shows a combination of emission from polycyclic aromatic hydrocarbons and absorption from acetylene. The spectrum also shows a broad absorption band in the 13-17 um region that has been observed in two other objects at higher resolution, where it separates into bands from a range of hydrocarbon molecules. The other four objects show an emission feature at 14 um in addition to strong silicate emission features. This feature lies at the boundary betwen the SL and LL modules, making SH observations essential to demonstrate that the 14 um features is not an artifact. The proposed observations will take 6.0 hours, and we are requesting the time as part of the IRS GTO allocation.

Spitzer Space Telescope - General Observer Proposal #3505

Mass loss from red giants: its development, dust properties, and dependence on the stellar parameters mass, luminosity and metallicity

Principal Investigator: Peter Wood
Institution: Australian National University

Technical Contact: Peter Wood, Australian National University

Co-Investigators:
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Patricia Whitelock, South African Astronomical Observatory
Rens Waters, University of Amsterdam
Albert Zijlstra, University of Manchester Institute of Science and

Science Category: extragalactic stellar studies
Observing Modes: IrsStare
Hours Approved: 31.0

Abstract:
We wish to obtain low resolution IRS spectra of highly evolved, low and intermediate mass stars in the Large and Small Magellanic Clouds. Our sample of stars consists of asymptotic giant branch (AGB) stars in both the general field of the Clouds and in clusters, and it complements the GTO samples of Houck and Kemper. The stars range from lower luminosity stars with small mass loss rates in the two clusters NGC419 and NGC1978 to dust-enshrouded stars in the "superwind" phase. The stars have been studied from the ground (mostly by members of this team) in order to determine spectral types, pulsation periods and amplitudes, and optical and near-infrared fluxes. Our aim is to use the IRS spectra to empirically determine the dependence of mass loss rate on stellar mass, luminosity, pulsation period and amplitude, and metallicity. We will also examine the dust properties as a function of mass loss rate, luminosity and photospheric chemical type. The AGB mass loss law resulting from this study will allow accurate AGB stellar evolution calculations to be made, meaning that reliable estimates can be made of the total mass loss from an AGB star, the stellar remnant mass, and the amounts of nucleosynthetic products ejected. Since the rate of mass return to, and enrichment of, the interstellar medium by low and intermediate mass stars depends critically on the mass loss rate and surface enrichment during the AGB phase, an accurate mass loss law will greatly enhance the reliability of galactic enrichment models. Our total request is for 31.4 hours.

Spitzer Space Telescope - General Observer Proposal #20357

Mass loss from AGB stars in local group galaxies

Principal Investigator: Albert Zijlstra
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Technical Contact: Mikako Matsuura, University of Manchester

Co-Investigators:
Mikako Mikako, University of Manchester
Maria Rosa Cioni, Royal Observatory of Edinburgh
John W. Menzies, South African Astronomical Observatory
Patricia A Whitelock, South African Astronomical Observatory
Peter Wood, Australian National University

Science Category: extragalactic stellar studies
Observing Modes: IrsStare
Hours Approved: 21.9

Abstract:
Mass loss from Asymptotic Giant Branch star is important both for stellar evolution and evolution of the interstellar medium. Mass loss rates have been measured for Galactic stars and Magellanic Cloud stars, but no measurements exist for metallicities [Fe/H] < -1. This is a crucial parameter range, because models predict a transition from dust-driven winds at higher metallicity to pulsation-driven at lower metallicity. Recent ground-based observations suggest that this transition may be more complicated: metal-poor oxygen-rich AGB stars show strongly suppressed abundances of dust precursor molecules (SiO), but metal-poor carbon stars show significant enhancements of molecules such as C2H2 and HCN, compared to Galactic stars. This may cause AGB mass loss at low metallicity to be largely dominated by carbon stars, with important imlpications for the dust input into the ISM. Here we propose a survey of luminous AGB stars in a number of nearby galaxies with [Fe/H] < -1. Only Spitzer can detect dust in these stellar populations, and allows to measure measure mass loss rates in this previously unexplored parameter range. We wil compare the measured rates against predictions from Bowen models and from commonly used parametrizations, and test for the occurence of the predicted transition.