The Spitzer Space Telescope First Look Survey – Ecliptic Plane Component
Thermal Observations and Preliminary Number Counts
January 30, 2004

The Spitzer Space Telescope First Look Survey – Ecliptic Plane Component (FLS-EPC) was executed on the spacecraft on UT 2004 January 21. These IRAC and MIPS observations of two 0.14 square degree fields were centered at a solar elongation as seen from Spitzer of 115º, and at 0º and +5º ecliptic latitude. The exposure time was 120 sec for the IRAC (8 µm) observations and 200 sec for the MIPS (24 µm) observations. Details of this program and the observing plan can be found at http://ssc.spitzer.caltech.edu/fls/eclip/. The AORs used for this program can be viewed in SPOT, using "View Program" with Program ID 98.

Our preliminary analysis of the reduced data is given below. This analysis is in no way exhaustive, but is provided at this time to help observers planning GO-1 observations of asteroids, or observations in the ecliptic plane between -5º to +5º ecliptic latitude.

Observations of Known Asteroids: Observed 8 and 24 µm fluxes

We have identified 10 known asteroids in the IRAC 0º field, and 4 known asteroids in the IRAC +5º field. The measured thermal fluxes (8 and 24 µm) for the 9 known asteroids in the 0º field that also had MIPS detections, and one, fainter, unknown asteroid, are given in Table 1. The uncertainties in these values are conservatively set at 15% for both IRAC and MIPS.

Table 1: Measured Thermal Fluxes for 9 Known Asteroids in the 0º Field

Object	8 µm flux (mJy)	24 µm flux (mJy)	V (apparent)	H
1995 BS3	5.6	41	18.1	13.5
2000 AX136	3.6	30	17.2	13.1
2002 WL7	2.7	23	20.1	15.6
1999 FZ24	2.3	19	19.1	13.8
1981 EV22	1.1	12	19.3	14.0
2001 QY 160	0.96	12	20.0	14.9
1999 AN21	0.90	11	19.1	14.2
1997 EU4	0.20	2.4	20.1	16.9
2001 SB182	0.22	1.9	21.1	15.9
Unknown	0.25	1.9	--	--

Asteroid Number Counts and Behavior With Ecliptic Latitude

For each of the two fields, we used mosaics of the three epochs of IRAC observation and created a composite Red Green and Blue image. In this RGB image, fixed sources appeared white, and moving targets were seen as red-green-blue linear sequences of sources. The slowest apparent motion observed in the known sample was 3.6″/hr.

Simulations of the apparent motion of main belt asteroids at the solar elongation observed by Spitzer suggest that only 5% of our sample had apparent motions smaller than this.

With this technique, we were able to convincingly identify by eye 19 (±4.3) sources in the 0º field and 16(±4) sources in the +5º field. Subsequent photometry measurements indicate that the faintest of these sources have 8 µm fluxes close to 0.08 mJy, and were detected with a S/N of ~10, in both fields. We note however that there are few sources detected by eye at this limit, so that we are likely not yet complete to this flux level, using this technique. If we consider asteroids observed down to flux levels of 0.1 mJy, our observed counts correspond to 124±29 asteroids per square degree at 0º latitude, and 100±27 asteroids per square degree at +5 degrees latitude.

To sensitivities of 0.1 mJy, our observed number counts are lower than the nominal values predicted by the model on the SSC website, although that model gives numbers that not considered reliable to better than a factor of three (http://ssc.spitzer.caltech.edu/documents/asteroid_memo.pdf ; Brooke, 2002). In the 0º field, we observe 4 times fewer asteroids than predicted, and in the 5º field, we observe half as many asteroids as predicted. The asteroid survey using ISO, by Tedesco and Desert (2002), yielded 2.5 times fewer asteroids than the SSC memo would have predicted. Tedesco and Desert (2002) would predict 25±5 asteroids in the FLS-EPS 0º field down to 0.1 mJy at 8 µm, in reasonable agreement with our results with Spitzer. Consequently, the observed asteroid counts in the 0º field are at the lower end of the Brooke model predictions, and close to those predicted by extrapolating the ISO asteroid counts (Tedesco and Desert, 2002). At this preliminary stage of analysis, observers should consider these observed number counts to be the lower limit of asteroids likely to be seen by Spitzer to 0.1 mJy, between -5º and +5º ecliptic latitude.

The Spitzer website asteroid model also predicts that the ratio of asteroids in the +5º field to that in the 0º field is ~0.5, down to 0.1 mJy at 8 µm. The observed ratio is ~0.8. However, significant Poisson errors due to our relatively small sample indicate that this ratio could be as high as 1.4, or as low as 0.5. We note also that we see an identical number of asteroids in both IRAC fields at 8 µm fluxes of 1mJy and lower (14 each). Due to small number statistics, the FLS-EPS number counts in this stage of analysis are not conclusive evidence for a more slowly decreasing population distribution with increased ecliptic latitude, although they are suggestive of this. Further analysis and observations would be required to get a more conclusive picture of asteroid scale height behavior at these wavelengths and flux limits, and to determine revised asteroid counts at ecliptic latitudes poleward of 5º.

Zodiacal Background in the Ecliptic Plane.

The FLS-EPC fields were also used to investigate the natural background brightness for Spitzer. The sensitivity of Spitzer is background-limited, primarily by the zodiacal light, except at the longest wavelengths and lowest galactic latitudes. None of the Spitzer instruments is optimized for absolute background measurements. IRAC absolute photometry in the data products is provided relative to the brightness of a dark patch that is monitored routinely and used for the sky-dark determination; the BCD absolute levels are those of the observed patch minus the sky-dark. (There is no internal absolute reference for IRAC photometry because the shutter is not being used in flight.)

However, for MIPS at 24 µm, the zodiacal light is so bright, the instrument sufficiently stable, and the absolute reference to cold interior of the telescope (using the scan mirror) is so dark, that the absolute photometry of the zodiacal light is relatively accurate. Using a long MIPS scan from 0º to 6º ecliptic latitude, we verified that both the brightness and the shape of the zodiacal light are reasonably predicted by the model implemented in SPOT. This model, which was derived from the COBE/DIRBE data, is the one that was used to generate the sensitivity estimates, so the backgrounds used in the sensitivity predictions in the Observers Manual are accurate enough for use in the GO-1 Call for Proposals.

In more detail, the background at 24 µm, as provided in the standard pipeline data products (calibrated using photometry on stars), was 5% brighter than the 24.0 µm SPOT model prediction. This is in extremely good agreement, and well within both the absolute calibration uncertainty and the possible color-correction from the stellar calibrators to the much-redder zodiacal light.

At 70 µm, the backgrounds are significantly different for different observations, due to a combination of instrumental offset, gain drift, or both; calibration of the MIPS Ge detectors is very challenging. The observations were not made in the Total Power Mode, which has not yet been commissioned. We find the variation from AOR to AOR was ~40%, and the observed brightnesses were ~40% higher than predicted by the model implemented in SPOT. This is adequate agreement for now, and we trust the COBE/DIRBE data (and therefore the model in SPOT) to be better-calibrated for absolute measurements than the early Spitzer/MIPS results presented here, because the design of the former was specifically for the purpose of absolute background measurements, using a rapidly-modulated cold shutter and baffling such that off-axis response is down by many orders of magnitude.

To compare the IRAC 8 µm data to the model, we first computed the background in the observed ecliptic fields, then added back in the average background in the sky-dark fields, given that all IRAC photometry is relative to the brightness of a faint sky patch near the pole. IRAC is thus technically unable to perform absolute photometry, and trending of the calibration observations has demonstrated a drift in the bias larger than the uncertainty in the background. Further, we currently believe that the IRAC calibration, which was performed using stellar photometry in a 10 pixel radius, does not correctly include the large-scale wings of the point spread function. Thus, even though the background brightnesses as observed in the FLS-EPS fields at 8 µm are 36% brighter than the model, we attribute nearly the entire difference to the absolute calibration: preliminary results on the full PSF suggest the stellar photometry is off by almost precisely this amount. As explained in the Spitzer Observer's Manual, this effect is already taken into account in our IRAC sensitivity calculations.

The zodiacal light at shorter IRAC wavelengths, and at MIPS 160 μm, is fainter and too difficult to measure accurately at this early stage.