Polarimetry of Galactic Bubbles

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ABSTRACT

The Galactic Plane Infrared Polarization Survey (GPIPS) has completed its second season of H-band (1.6 micron) data collection using the Mimir near-infrared instrument in linear polarimetry imaging mode on the 1.8m Perkins Telescope outside Flagstaff, Arizona. This key project for the Perkins Telescope seeks to answer important questions about the nature of the magnetic field and the aligned dust grains used to trace the field for small-scale star-forming regions, medium scale molecular and atomic cloud regions, and large-scale Galactic spiral arm and interarm regions. One of the goals for this season was to obtain polarimetry around a sample of the recently discovered Galactic bubbles in GLIMPSE. These bubbles have high eccentricities that suggests some astrophysical phenomenon is preferentially elongating them. Linear polarimetry of stars inside and outside the bubbles will trace the Galactic magnetic field and its interaction with these bubbles. This will help elucidate the interaction of the Galactic magnetic field with other dynamic forces.

Subject headings: infrared: ISM — ISM: bubbles — ISM: magnetic fields — ISM: structure — polarization

Data from the Galactic Legacy Infrared Mid-Plane Survey Extraordinaire (GLIMPSE; Benjamin et al. 2003) database were recently used to discover 322 ring-shaped or bubble features (Churchwell et al. 2006), particularly in the 8.0 μm band. These features, which are likely due to PAH emission, were suggested to be three-dimensional bubbles projected onto the plane of the sky. HII regions and open clusters overlap with 25% and 13% of the bubbles, respectively. Churchwell et al. (2006) also show that about 65% of the bubbles have high eccentricities ($0.55 \leq e \leq 0.85$), as shown in their Figure 13 (Figure 1 here). The preponderance of high eccentricities suggests an astrophysical phenomenon producing elongated bubbles.

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Our near-infrared project will probe the magnetic field inside and around 34 of the larger GLIMPSE bubbles. Smaller bubbles were excluded because GPIPS will not provide adequate sampling inside the bubbles. These larger bubbles will be probed internally by a median of 26 GPIPS polarization stars, and outside by typically 212 GPIPS stars, within 2 bubble radii (see Figure 2[2]).

All observations were performed with the Mimir instrument (Clemens et al. 2007) on Lowell Observatory's 1.8 meter Perkins telescope. H-band (1.6 μm) polarimetric images were obtained with a fixed wire grid and a rotatable half-wave plate combination at position angles of 0, 45, 90, and 135 degrees to generate Stokes U and Q vectors for visible stars. Each $10' \times 10'$ field of view was observed in six sky-dithered positions, providing complete coverage for most of the field. Adjacent fields overlap by $1'$, providing complete coverage for bubbles larger than the instrument field of view. Polarization percentage and position angle will be calibrated using known polarimetric standards (Whittet et al. 1992). Extensive detector linearity and flat-fielding corrections, detailed in Clemens et al. (2007), bring the polarization uncertainty under 0.3% for stars brighter than H=12.

Complementary data sets are used to deduce distance and kinematic information. In particular, the ^{13}CO spectra from the recently completed Galactic Ring Survey (Jackson et al. 2006) will be searched for corresponding bubble features and can provide kinematic distances as well as bubble expansion velocities for molecular gas components. Kinematic distances are constrained because only bubbles at the near kinematic distance are visible in GLIMPSE images (Churchwell et al. 2006).

When the polarization maps are complete and magnetic fields are revealed, this information will be overlaid on the GLIMPSE bubble images to gauge the influence each bubble has on the local interstellar medium and Galactic magnetic field. These combined data will be used to answer several key questions: How is the Galactic magnetic field affected by strong stellar winds? Is the Galactic magnetic field capable of resisting strong stellar winds? What role do magnetic fields play in the star formation observed at the boundaries of some bubbles?

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[2]http://www.astro.wisc.edu/sirtf/bubbles/north/N065_03500+033_mosaic_1234.jpg

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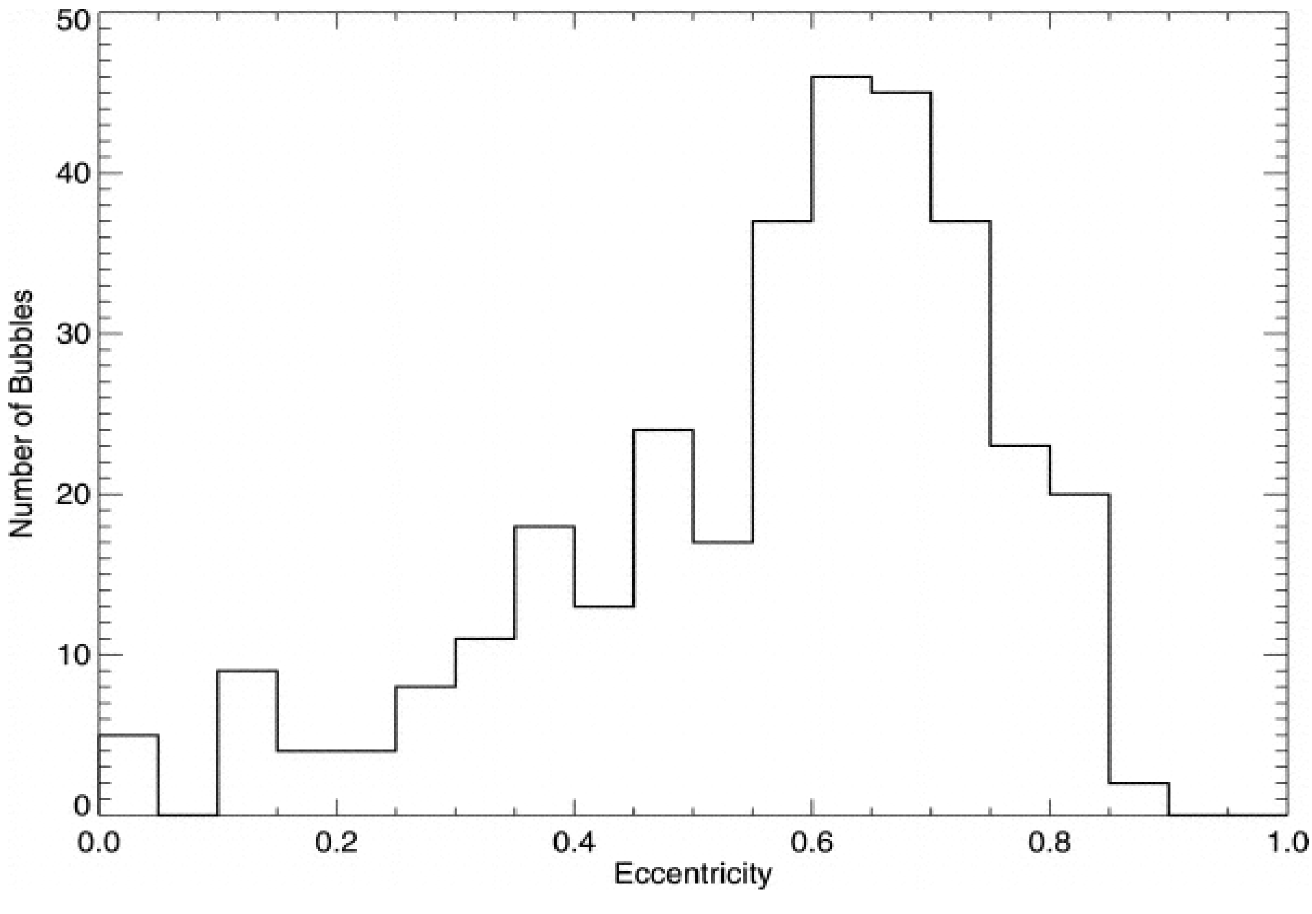

Fig. 1.— Figure 13 from Churchwell et al. (2006) showing the distribution of bubble eccentricities. The highly offset distribution indicates a systematic astrophysical phenomenon causing bubbles to preferentially elongate. This average eccentricity of bubbles sampled in this project will be 0.61. Figure reprinted with permission.

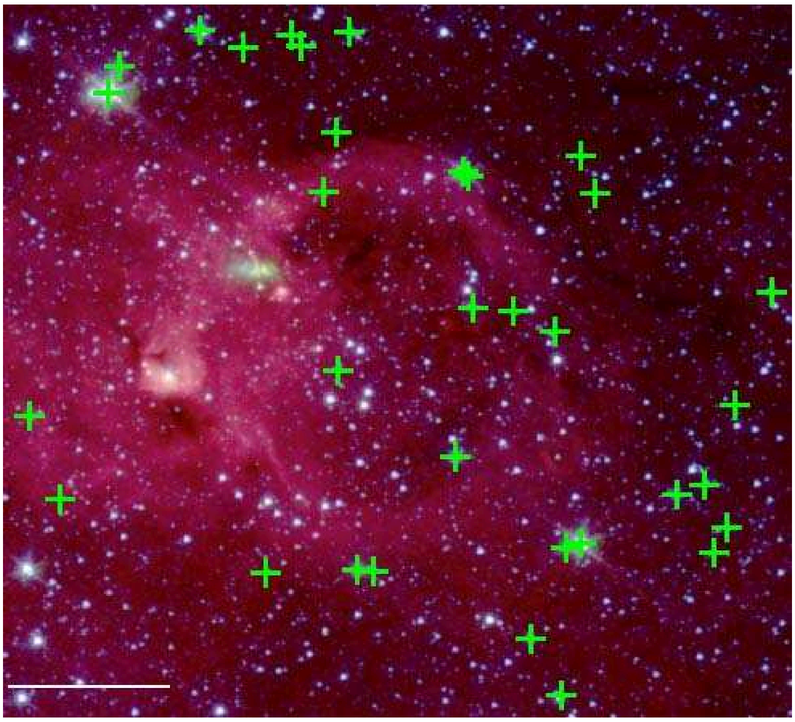

Fig. 2.— Bubble N65 (l=35.0, b=0.3) from Churchwell et al. (2006). This bubble has average radius of 2.15 arcmin and an eccentricity of 0.49. Green crosses have been overlaid on stars brighter than H=12 (from 2MASS) that will be measured. The white bar represents 2 arcminutes.