Planetary Nebulae in our Galaxy and Beyond
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Planetary nebulae in the GLIMPSE survey

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Abstract. We report the observations of planetary nebulae in the *Spitzer Space Telescope Galactic Legacy Infrared Mid-Plane Survey Extraordinaire (GLIMPSE)* survey. The distribution of warm dust is clearly shown in these images.

Keywords. planetary nebulae: general, infrared: general, surveys

1. Introduction

Planetary nebulae (PNs) have high dust content and radiate strongly in the infrared. For young PNs, the dust component accounts for ∼1/3 of the total energy output of the nebulae (Zhang & Kwok 1991). The typical color temperatures of PNs are between 100 and 200 K, and at $\lambda > 5$ μm, dust begins to dominate over bound-free emission from the ionized component. Although PNs are traditionally discovered through examination of photographic plates or Hα surveys, PNs can also be identified in infrared surveys by searching for red objects with a rising spectrum between 4-10 μm. In this paper, we present images of PNs observed in the *Galactic Legacy Infrared Mid-Plane Survey Extraordinaire (GLIMPSE)* survey, one of the Legacy Science Projects of the *Spitzer Space Telescope (SST)*.

2. Data processing

The *GLIMPSE* survey was carried out over the period from March 9 to November 1 in 2004 with the *Infrared Array Camera (IRAC)* on the *SST*. IRAC has four wavelength bands centered at 3.6, 4.5, 5.8 and 8.0 μm, each of which has a field of view of $\sim 5.2' \times 5.2'$. The pixel size in all four bands is $\sim 1.2'' \times 1.2''$. The FWHM of the point-spread functions are 1.63", 1.70", 1.85" and 1.94" at 3.6, 4.5, 5.8 and 8.0 μm bands, respectively. The *GLIMPSE* survey covers the inner two-thirds of the Galactic plane ($\ell = \pm 10^\circ - 65^\circ, b = \pm 1^\circ$; total area ~ 220 deg^2) in all four IRAC bands. Details of the survey are described in Churchwell *et al.* (2004).

The *GLIMPSE* data processing effort starts from the basic calibrated data supplied by the Spitzer Space Center to produce independent mosaics using the Montage package (montage.ipac.caltech.edu). The mosaic images were corrected for instrumental artifacts such as zodiacal background, excessive cosmic ray hits and other instrumental and downlink problems. Counterparts of PNs from the *Edinburgh/AAO/Strasbourg Catalogue of Galactic Planetary Nebulae* were then searched for and identified in the *GLIMPSE* mosaics.

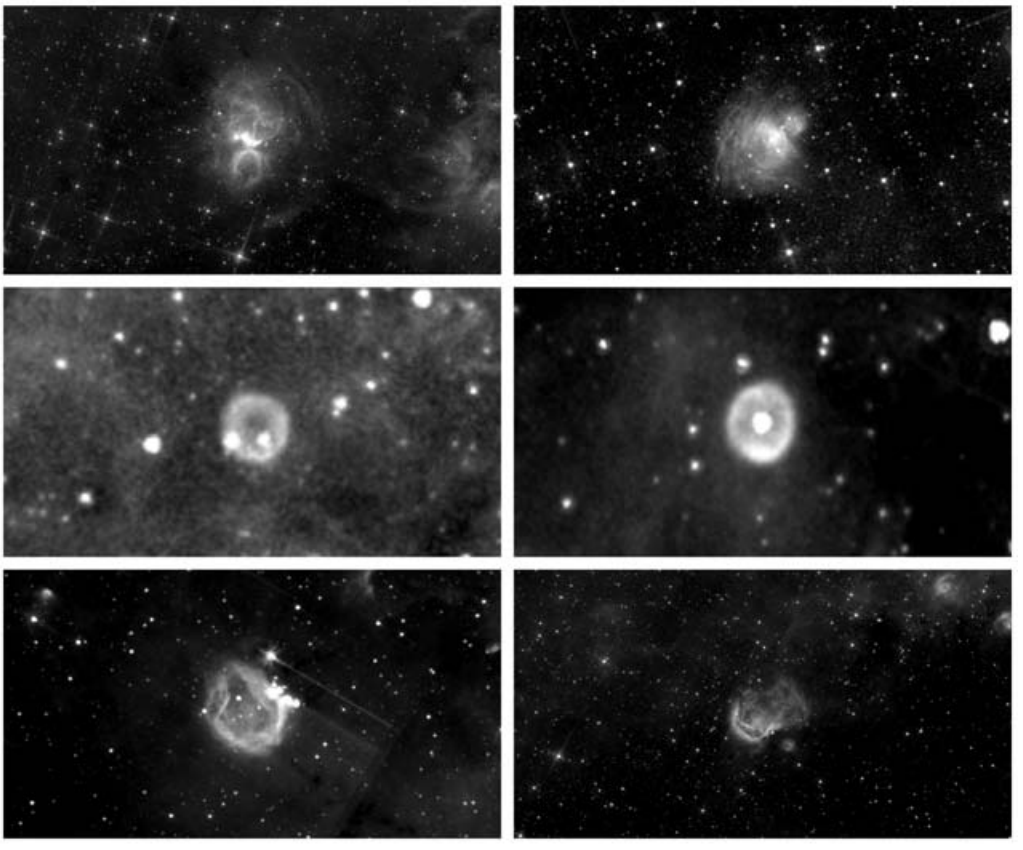

Figure 1. *IRAC* images of 6 PNs observed in the *GLIMPSE* survey (upper left: PNG 328.5 − 00.5(5.8 μm), upper right: PNG 298.4+00.6 (5.8 μm), middle left: PNG 040.3-00.4 (8 μm), middle right: PNG 333.9+00.6 (8 μm), lower left: PNG 321.3 − 00.3 (8 μm), lower right: PNG 309.5 − 00.7 (5.8 μm).

3. Results

A total of 31 counterparts to PNs were found in the *GLIMPSE* survey. Most are southern PNs catalogued by the AAO/UKAST Hα survey. Many of the PNs have a rising spectrum in the 3-8 μm range and are brightest in the 8 μm band. The images of six PNs are shown in Figure 1. Since many HII regions are also dusty, we cannot be certain that these *GLIMPSE* sources are PNs. Their nature has to be followed up by ground-based optical imaging and spectroscopy.

We can see that the infrared morphologies range from typical shell-like structures (e.g., PNG 040.3-00.4, PNG 321.3-00.3) to bipolar structures (e.g., PNG 298.4+00.6). In the case of PNG 328.5-00.4, the two bipolar lobes are bright in the *IRAC* images, showing that there is dust emission in the lobes. However, the two lobes are separated by a dark lane, which must contain dust too cold to radiate at 8 μm. The distribution of such cold dust in the equatorial regions needs to be imaged by a far-infrared imager, e.g., with the *FORCAST* instrument of *SOFIA* or submm interferometers such as *ALMA*.

References

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