Abstract

We present initial results of a program to determine the properties of Planetary Nebulae (PNe) in the Spitzer SAGE survey of the Large Magellanic Cloud (LMC). We have constructed IRAC mosaics of a sample of PNe in the Leisy et al. (1997) catalog, and we compare the images to previous HST imaging at optical wavelengths. We present color-color plots and IRAC images of the detected PNe.

Data and Analysis

The data were obtained at part of the SAGE Legacy survey of the LMC (Meixner et al. 2006). The IRAC (Fazio et al. 2004) camera was used to obtain 4x12 sec frames at each position at 3.6, 4.5, 5.8, and 8.0 µm. For each of the PNe in the Leisy et al. (1997) sample, we measured 1 arcsec diameter circles of SAGE data in a few arcmin region around the position. The 3 arcsec diam and that were used to obtain aperture photometry of all of the sources in the field, and a hand-edited catalog of the IRAC photometry was constructed for each field. The nearest source less than 1.5 arcsec from the Leisy et al. catalog position was assumed to be the PN. Out of a total of 233 objects that were in the SAGE survey region, 213 had a detection in one or more IRAC bands, and 118 had detections in all four IRAC bands.

For the recently released Reid & Parker (2006; hereafter RP2006) LMC PNe, we searched the SAGE catalog for sources detected in all IRAC bands that were close to the RP2006 new PNe positions (within 1 arcsec).

Since the SAGE catalog excludes extended sources, we are selecting only the point-like PNe from the RP2006 list. We are planning to redo the photometry for these objects from the SAGE mosaics to extract the extended sources as was done for the Leisy et al. sample.

The Galactic PNe data plotted in the color-color diagram in the box to the right were obtained at part of the GTO Survey of PNe (Hora et al. 2004). These nebulae are in general extended over many arcmin in diameter. The flux of a nebula was estimated by summing over multiple IRAC bands. The fluxes were then corrected for foreground extinction from field stars.

IRAC Colors of PNe

The IRAC 3.6 – 4.5 vs 4.5 – 8.0 µm colors of the PNe detected in all four IRAC bands are shown in the figure to the right. The Galactic PNe from the Houck et al. GTO survey are shown at filled green diamonds, the sample from Leisy et al. at the blue squares, and the new objects from the Reid & Parker survey are shown as red squares. The objects are mostly in the 0.5 – 1.2 range at [3.6] – [4.5] and in the 1.3 – 1.9 range of [4.5] – [8.0] color. Some of the PNe with IRS spectra in the last to the right are labeled in the figure. The PNe that exhibit strong PAH and/or warm dust continuum are on the right side of the plot (larger [4.5] – [8.0] color), as one might expect, and have [3.6] – [4.5] colors closer to +1. Strong forbidden line emission in the 8.0 µm band also results in objects appearing on the right side of the plot. However, the objects with no continuum dust emission have lower [3.6] – [4.5] values. The PNe with strong forbidden line emission and no PAH or dust continuum emission, for example SMP53, are on the left side of the plot.

The figures in the box at the far right on this poster show IRS spectra of several LMC PNe from the Houck et al. GTO program 103 that were in the public archive. Several emission components are identified in the SEDs spectrum that are common to many of the PNe. [Ne VI] line is also sometimes a significant contributor to the flux in the 8.0 µm band (e.g., as for SMP81 and SMP78). These objects were likely selected in part for their bright IR emission, so it is not surprising to see many with strong PAH and dust continuum emission.

The Galactic and LMC PNe have similar distributions in the IRAC color-color plot. There are several biases in the samples that could affect the distribution of sources. The Leisy et al. and RP2006 samples are optically selected. Several more evolved objects with bright emission lines are preferentially detected. Because the IRAC data from the RP2006 objects were obtained from the point source catalog, extended objects or those with complicated backgrounds are not plotted. For the sample, every object was selected from images that were 5.5 arcmin by 5.5 arcmin, so fainter objects with central star-dominated colors would be included.

The figure to the right shows an example of what components contribute to the flux of a PN as measured by IRAC. The ISO spectrum of NGC 7027 is plotted with the IRAC bandspass overlaid. The spectrum includes many of the strong emission lines from the ionized zone and PNe of the young PN. This nebula also exhibits H2 emission in regions outside of the ionized zone which is not evident in this spectrum.

References

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