A Survey for New PNe in the Southern Galactic Bulge

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Abstract: We present the results of a deep and uniform narrow-band Hα imaging survey for planetary nebulæ (PNe) in the southern galactic bulge. The goal of this survey was to obtain a sample of bulge tracers which can be used to study the dynamics of the Milky Way bulge (Beaulieu 1996).

Keywords: Galaxy: bulge — ISM: planetary nebulæ — surveys

1 The 1·0 m Survey

We have chosen PNe as the tracers for our survey because they are less affected by metallicity bias than most other tracers, and they are strong emitters in Hα which makes their velocities easy to measure.

The Low Dispersion Survey Spectrograph (LDSS) of the Anglo-Australian Observatory was attached to the 1·0 m telescope of Siding Spring Observatory and was used as a focal reducer (without grism). This instrument, with 100 mm interference filters and a 1024 x 1024 CCD, gives a useful circular field of 30 arcmin at 2·35 arcsec per pixel. We conducted the survey in Hα (λ6562 Å, FWHM 19 Å) and the nearby continuum (6450 Å, FWHM 42 Å).

The 1·0 m telescope optical imaging survey covers the region of the southern galactic bulge, $l = \pm 20°$ and $b = -5°$ to $-10°$, chosen because of its lower extinction relative to the northern bulge. By uniformly spacing our 30 arcmin fields of view over the area $l = \pm 20°$ and $b = -5°$ to $-10°$, we produced a grid of 488 fields. In two seasons of observation, we covered 94% of the grid (458 fields). In addition, we obtained 40 fields in the equivalent area of the northern bulge. In Figure 1, the filled circles represent the fields we have observed. Each circular field covers roughly half of the total area associated with each grid point. Added together, they represent about 1% of the far-IR flux from the bulge (Section 3).

In studying the bulge of the Milky Way, we are challenged with the difficulty of finding Hα emitters in dense star fields. The most straightforward method to detect our Hα candidates was to combine
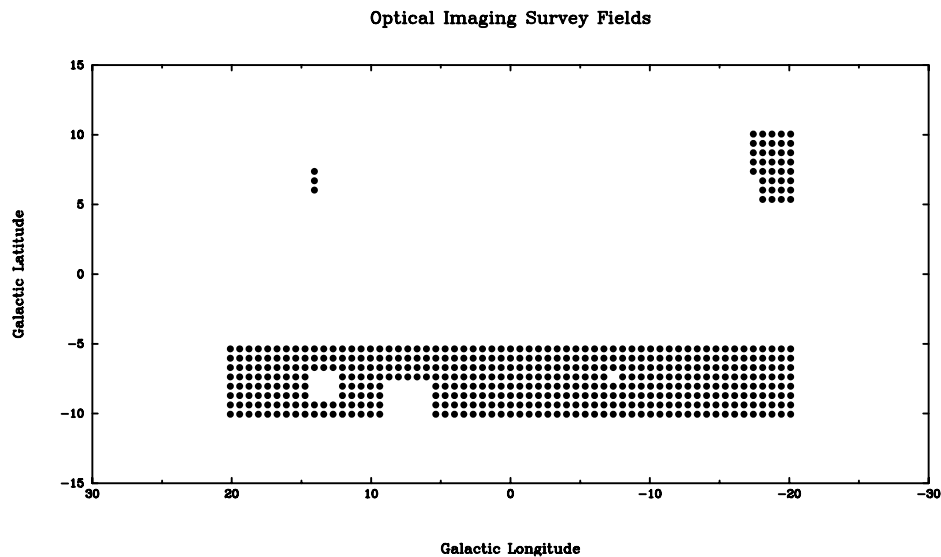

Figure 1—Optical Imaging Survey grid with fields observed.

the two Hα frames and then *divide* the Hα image by the continuum image for each field.

After a thorough and systematic visual examination of the quotient images for our 498 fields, we obtained a total of 148 Hα detections. We used the Acker et al. (1992) catalogue of planetary nebulæ (which is the most up-to-date) in order to identify already known PNe. This cross-check yielded 97 new candidates.

2 Spectroscopy Follow-up

Using the 74-inch (188 cm) telescope at Mount Stromlo Observatory, we obtained spectra for the 97 new Hα objects detected in our $1 \cdot 0$ m telescope imaging survey. We have also re-measured radial velocities for a subset of 317 PNe from the Acker et al. (1993) Catalogue in the more extended region $l = \pm 30°$ and $b = \pm (3 \cdot 3°$ and 15°, *two areas*): this larger sample is also being used for some dynamical comparisons, although the discovery process for this larger sample is much less homogeneous.

Table 1. Summary of the classification for the 97 new candidates

Objects	Counts
PN	53
Prob. PN	3
Symbol. star	14
Prob. symb. star	3
dMe	3
CV?	1
Spurious	20

We used the Boller and Chivens spectrograph with the 600 l mm^{-1} grating blazed at λ 7500 Å in first order and the GEC 385×578 UV coated CCD. The spectrograph slit width was 2 arcsec. This CCD has a pixel size of $22 \cdot 5 \mu$ and a readout noise of 10. We binned the CCD with a factor of 3 along the slit and a factor 1 in λ. The grating was set to have a wavelength coverage from λ 6200 Å to λ 6800 Å. A GG 475 filter in the beam was used to cut-off light from the second order blue. This setup gave a wavelength scale of about 1 Å pixel^{-1} (50 km s^{-1}). Table 1 summarises the final count of our 97 new candidates.

There were 193 catalogued PNe with published radial velocities. Figure 2 show a comparison of our velocity values against the catalogued velocities. Apart from a few outliers, we find good agreement with the catalogued values. Our measurement error is 11 km s^{-1}.

3 Comparison with COBE

Using the COBE/DIRBE $1 \cdot 25$, $2 \cdot 2$ and $3 \cdot 5$ μm images, we found that there is no significant difference between the longitude distribution of the PNe and the COBE light in the zone of our deep survey.
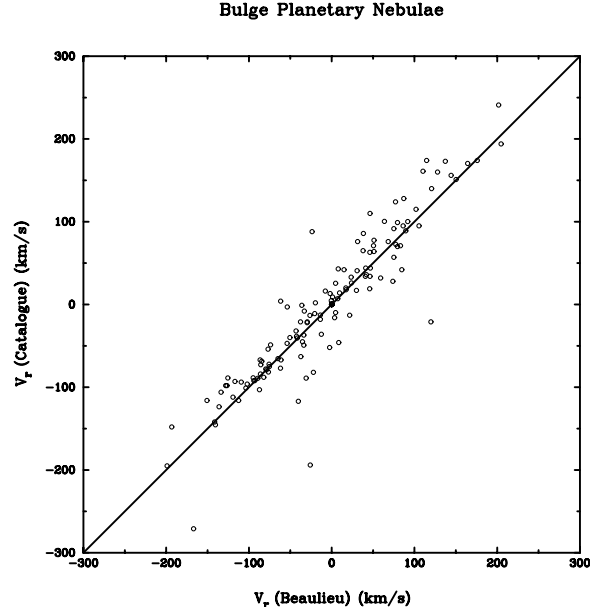

Bulge Planetary Nebulae

Figure 2—Comparison between the velocity values obtained from the 74-inch telescope and the catalogued values.

Also, we find that the extinction in our surveyed fields is not severe and that its distribution is fairly uniform. A two-tailed K-S test shows that there is no significant difference between the longitude distribution of the PNe and the COBE light in the zone of our deep survey.

4 Discussion

The planetary nebulæ of the galactic bulge constitute the largest and nearest population of PNe. Our survey has doubled the number of known PNe in the surveyed region. Although much of our survey was done under nonphotometric conditions, subsequent photometric observations by Dopita indicate that our survey is at least two magnitudes deeper than previous work. If the luminosity function of PNe in the direction of the galactic bulge increases in the way suggested to be the case for LMC PNe, then our survey should have found at least 200 new objects, but we found only 56.

There are two possibilities for this lack of PNe: it could be that the PNe are dust-enshrouded because of their high metallicity, or that the PNe are associated with a low mass central star so that the nebula has expanded and become optically thin in the timescale over which the central star becomes hot enough to ionise it.

We have started a program to address the question of which of these two evolutionary scenarios apply to the objects in our newly-discovered sample by obtaining accurate photometry. Such data will provide a measure of the physical size, the reddening, an estimate of the luminosity in the ionising field that is absorbed in the nebula, a determination of the excitation class, and estimates of the degree

of optical thickness of the nebula and the nebular abundances.

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