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# Planetary nebulae in the Galactic Bulge

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**Abstract.** An on-going survey of Bulge planetary nebulae is described. Evidence is found for a non-standard extinction law towards the Galactic Bulge.

## 1. Introduction

The PN population in the Bulge is the only sample of Galactic PNe with known, uniform distances, and is close enough that the nebulae can be resolved. The observational database for Bulge PNe is still far from complete. Even elementary data such as diameters is often not or only poorly known. We have initiated a large observational survey of Bulge PNe (using HST, the NTT and the AAT), to obtain imaging and spectroscopy for all known Bulge PN. Imaging data yield: diameters na dmorphology, absolute line fluxes, stellar magnitudes and Zanstra temperatures, again for well resolved objects. High resolution spectroscopy gives information on the internal velocity fields, dynamical ages and stellar mass.

## 2. Morphology

Example HST images of Bulge PN are shown in Fig. 1. All images are on the same scale (the largest is 3 arcsec across) and are at similar distance. The most extreme morphology is shown by the most compact object. These images provide some support for the suggestion that bipolarity is related to slower expanding, dense torii.

If both the expansion velocity and the diameter are known, a dynamical age can be calculated. We make corrections for the slower expansion during the pre-PN phase and the non-uniform velocities. The resulting age can be compared with the temperature of the central star. The time scale for the temperature increase of the star should be the same as the time scale for the nebulae expansion. This is the most sensitive technique to measure relative stellar masses. We have sofar obtained 150 echelle spectra. The mean final mass is $0.61 M_\odot$ for Bulge PNe.

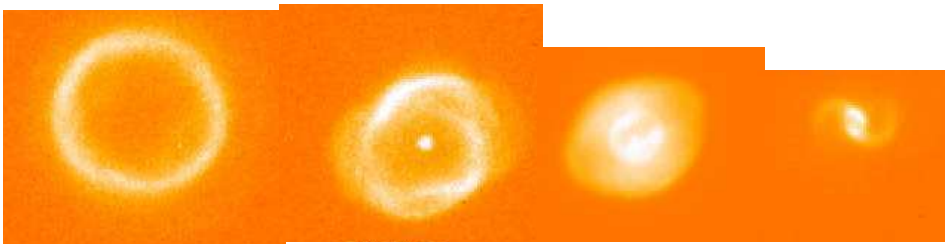

Figure 1. Four HST H$\alpha$ images of Bulge PNe: from left to right, 357.2+02.0, 358.7−05.2, 006.1+08.3, 356.8+03.3

## 3. Extinction

The extinction towards a PN can be determined in two ways: the hydrogen line ratios, and the ratio between the radio flux and hydrogen line flux. The former measures the reddening and the latter the absolute extinction. Radio fluxes come primarily from VLA surveys. Fluxes below 10 mJy have been shown to be less reliable. The H$\alpha$/H$\beta$ decrement is taken from the ESO-Strasbourg catalog. Absolute line fluxes are measured from our images.

The ratio between the two determination gives $R_V = A_V/E(B-V)$. Fig. 2 shows that a value significantly lower than the 'universal' $R = 3.1$ is derived. This discrepancy was first noted by Tylenda et al (1992). Udalski (2003) also finds evidence for anomolous extinction from stellar colours. We find an average value of $R_V = 2.0$, with a trend of increasing $R$ with increasing extinction. This suggests an anomolous, steep extinction law for the low-obscuration line of sights towards the Bulge, indicative of dust with small grain sizes.

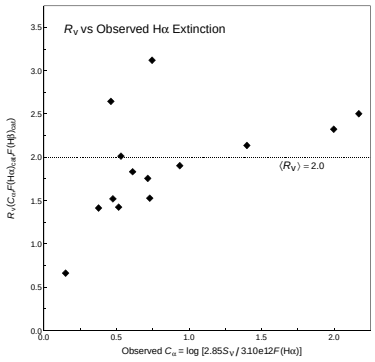


Figure 2. Extinction law coefficients for Bulge PNe

## References

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Udalski A., 2003, ApJ, 590, 284