The Dynamics of PNe Halos and the Timescale Correlation Distance

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We present deep narrow-band CCD images of four PNe obtained with the Palomar 5–m telescope in the light of [N II]λ6584 + Hα and [O III]λ5007. Several previously undetected structures are found, including faint multiple envelope structures. The inclusion of these sources with data for other multiple envelope PNe published in the literature permit an evaluation of the relationship between PNe 'shells' and the thermal pulses of the PN nucleus.

We study the relationship between two timescales for PNe with detached halos. The first is the dynamical timescale between successive envelopes, τ_{dyn}:

$$\tau_{\rm dyn}(d) = (\frac{\theta_{\rm o}}{v_{\rm o}} - \frac{\theta_{\rm i}}{v_{\rm i}})d$$

where θ is radius and v the expansion velocity of the inner and outer shells (indexed by the subscripts i and o, respectively), and d is the distance to the nebula. The second timescale of interest is the nuclear interpulse timescale, $\tau_{\rm ip}$:

$$log\tau_{\rm ip}(d) = 5.19 - \frac{L(d)}{1.78 \times 10^4},$$

(Frank, van der Veen, & Balick 1994; Vassiliadas & Wood 1994) where $\tau_{\rm ip}(d)$ is in years and $L(d)$ is the luminosity of the central star in $L_\odot$ which was computed assuming a distance of d.

Our analysis of the Palomar targets plus the PNe with multiple halos compiled by Frank, van der Veen & Balick (1994) and Stanghellini & Pasquali (1995) indicate that the deviations from the relation $\tau_{\rm dyn}(d_{\rm SH}) = \tau_{\rm ip}(d_{\rm SH})$ can be explained by the uncertainty in the Shklovsky distance, $d_{\rm SH}$, to individual PNe, which is approximately a factor of $\sim$2. By imposing the constraint $\tau_{\rm dyn}(d_{\rm TC}) = \tau_{\rm ip}(d_{\rm TC})$, and solving the above equations with a Newton-Raphson method, we find it possible to derive a distance, which we name the *timescale correlation distance*, $d_{\rm TC}$.

One of the desirable properties of $d_{\rm TC}$ is that the distance is relatively insensitive to large uncertainties in the observables used in the computations. An analysis by Hajian *et al.* (1997) indicates that in $d_{\rm TC}$ is typically uncertain by $\approx$20%. The computational ease and the high accuracy and robustity of $d_{\rm TC}$ suggest that the Timescale Correlation Method is a powerful tool for acquiring the distances to PNe with detached halos.

REFERENCES

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