The Structure and Kinematics of Bipolar Planetary Nebulae

W. G. Weller and S. R. Heathcote
Cerro Tololo Interamerican Observatory
National Optical Astronomy Observatories

We have obtained high-dispersion, long-slit echelle spectra at closely spaced intervals across the face of the bipolar planetary nebulae NGC 2440, NGC 6302 and Mz-3. Deep monochromatic images of these objects in lines from high (HeII, [OIII]), intermediate (HI, [OII]) and low ([NII], [SII]) excitation species have also been acquired. Taken together, these data permit us to construct self-consistent spatio-kinematic models of these nebulae and to investigate the spatial variations of excitation conditions within them.

These nebulae possess several unifying characteristics: (1) By definition they all show bi-lobate morphology; (2) All of them exhibit a disk or torus of dense material lying in the mid plane of the nebula. In NGC 2440 this disk is fully ionized, while in the other nebulae it is predominantly neutral; (3) They all show to differing but considerable extent, a remarkable degree of mirror symmetry, not only in their morphology, but also in their velocity structure; MZ-3 is the most highly symmetrical, and NGC 6302 is the least; and (4) The low surface brightness outer lobes all show expansion velocities in excess of 70 km/s, highly supersonic for a gas at a temperature of $< 10^4$ K.

Our data can be interpreted within the frame work of current models of the formation of PN through the action of a fast wind blown by the central star upon the expanding, axialy symmetric remnant of its red giant envelope. In this "colliding wind" model the dynamical evolution of the nebula is predominantly controlled by the parameters of the red giant mass loss. The observed symmetry of the nebulae studied, thus implies a consider-able degree of both axial and bi-lateral symmetry in the flow parameters of the slow wind.

S. Torres-Peimbert (ed.), Planetary Nebulae, 180.