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Interferometric Observations of OH and H_2O Masers in Protoplanetary Nebulae Imaged with HST - A Unique Diagnostic of their Spatio-Kinematic Structure

Raghvendra Sahai

JPL, California Institute of Technology, Pasadena, CA 91109

Mark J. Claussen

NRAO, Socorro, NM 87801

Mark Morris

University of California, Los Angeles, CA 90095

Recently, high-resolution imaging surveys of young planetary nebulae (PNe) and protoplanetary nebulae (PPNe) have revealed that the majority of these objects are characterised by multipolar bubbles distributed roughly point-symmetrically around the central star (e.g. Sahai & Trauger 1998, Sahai 2000). Sahai & Trauger (1998) have proposed that episodic high-speed jet-like outflows, operating during the protoplanetary or very late-AGB phase, are the primary agent for shaping PNe. OH and H_2O masers provide a unique and crucial probe of the kinematics of the circumstellar material in PPNe, because of the general lack of other emission-line diagnostics. Here we present new results from our ongoing study of PPNe using *HST* images with interferometric OH & H_2O maser-line data to unravel their detailed spatio-kinematic structure (e.g. Sahai et al. 1999a, Sahai, Claussen, & Morris 2002).

The "Water-Fountain Nebula", IRAS16342-3814 (hereafter IRAS1634), is a PPN belonging to a small class of unusual evolved stars with high velocity outflows traced in either or both of radio H_2O and OH maser line emission (e.g. Likkel & Morris 1988). The *HST* images of this PPN show a bipolar nebula – two bright lobes separated by a dark waist (Fig. 1 & Sahai et al. 1999b). The highest velocity OH features ($\sim$70 km s^{-1}) are clustered around the base of the lobes and lower velocity features are found near the waist. We recently obtained VLBA observations of the H_2O emission, and find that it is concentrated in two blobs separated by $3''.36$ along the optical axis[10]. The blobs consist of numerous, closely spaced components, with radial velocities spanning 187 to 169 km s^{-1} in the red-shifted blob, and -62 to -69 km s^{-1} in the blue one. Using the OH data, we

[10]the orientation of the H_2O maser axis is significantly different from that derived from VLA data (Sahai et al. 2002) taken 2 weeks prior to the VLBA run; we think that this is discrepancy is most likely due to some error(s) in the VLA data calibration for this rather low declination source

estimated an inclination of the nebular axis relative to the line-of-sight, of $\sim$50°, implying that the intrinsic speed of the H_2O jet is $\sim$190 km s^{-1}. The location of the H_2O maser blobs just beyond the tips of the corresponding optical lobes, indicates that these masers delineate the dense, warm, post-shock regions where the high-velocity polar jet strikes the prior AGB wind. The optical lobes are cavities excavated in the AGB wind by the jet.

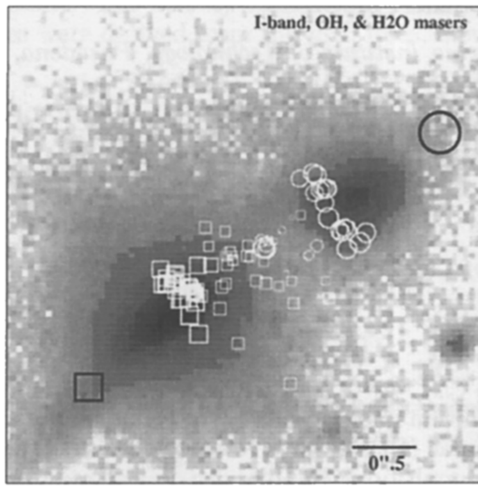

Figure 1. HST/WFPC2 scattered-light image (reverse grey-scale) of IRAS16342-3814 overlaid with locations of maser emission features in the OH 1612, 1665, & 1667 MHz (white symbols) and H_2O 22 GHz (black symbols) transitions. Blue/red shifted featurs are shown as squares/circles with sizes proportional to the outflow velocity and cover a range of 135 km s^{-1} in OH, and 246 km s^{-1} in H_2O.

Scheduled multi-epoch VLBA observations of the H_2O maser spots in IRAS1634 will enable us to measure their proper motions, which together with their radial velocities will help us to contrain the distance to this object.

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