*Cosmic Masers - from OH to $H_0$*
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# Imaging the water masers toward the $H_2O$-PN IRAS 18061−2505

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**Abstract.** It has been suggested that the presence of disks or tori around the central stars of pre Planetary Nebulae and Planetary Nebulae is related to the collimation of the jet that are frequently observed in these sources. These disks or tori can be traced by the maser emission of some molecules such as water. In this work we present Very Large Array (VLA) observations of the water maser emission at 22 GHz toward the PN IRAS 18061−2505, for which the masers appear located on one side of the central star. For comparison with the observations, we present a simple kinematical model of a disk rotating and expanding around the central star. The model matches qualitatively the observations. However, since the masers appear only on one side of the disk, these results are not conclusive.

**Keywords.** (ISM:) planetary nebulae: individual (IRAS 18061−2505), ISM: jets and outflows, masers

## 1. Introduction

The standard scenario for explaining the last stages of the evolution of low- and intermediate-mass stars includes the presence of a massive stellar wind that could reach mass-loss rates as high as $10^{-4}$ $M_\odot$ $yr^{-1}$ at the end of the Asymptotic Giant Branch phase. Subsequently, a tenuous fast stellar wind takes over. The latter interacts hydrodynamically with the former, piling up the gas and forming a circumstellar shell. When the central star becomes hot enough, the UV radiation ionizes the circumstellar shell. At this point, it is said that the star enters the planetary nebula (PN) phase. This model explains the formation of spherical PNe, however it fails to explain the formation of narrow-waist bipolar PNe. Many of this type of PNe exhibit a dark lane in the equatorial region that usually is traced by molecular gas and dust emission. It has been proposed that this high-density equatorial structure works as a nozzle that would squeeze the fast stellar wind toward the polar directions, forming the bipolar morphology. On the other hand, it has also been proposed that it is possible that, as a result of a binary system, an accretion disks forms in the central region of the PN. Similarly to the star forming

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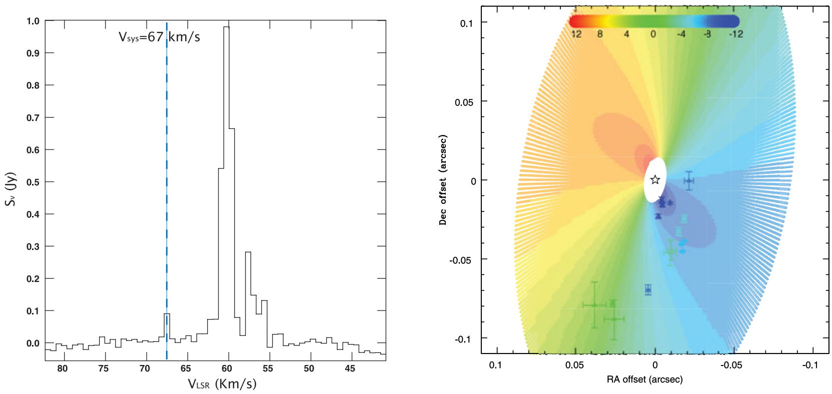


**Figure 1.** (Left) VLA water maser spectrum of IRAS 18061-2505. (Right) Modeling of the maser emission in terms of a rotating and expanding disk.

regions, the accretion disks leads to the formation of fast collimated jets that interact with the circumstellar envelope, giving origin to bipolar morphologies (e.g. Reyes-Ruiz & Lopez 1999).

The maser emission has proven to be a very useful tool to trace and study structures around evolved stars. So far, water maser emission has been detected in three young PNe: K 3−35 (Miranda *et al.* 2001), IRAS 17347−3139 (de Gregorio-Monsalvo *et al.* 2004) and IRAS 18061−2505 (Gómez *et al.* 2008). All three PNe exhibit a bipolar morphology and the first two objects seem to have disks traced by the water masers (Uscanga *et al.* 2008; Tafoya *et al.* 2009). IRAS 18061−2505 shows well defined bipolar lobes seen in H$\alpha$, separated by a clear narrow waist (Miranda *et al.* 2012). In this work, we present the results of interferometric observations of the water masers toward IRAS 18061−2505.

## 2. Results and Conclusions

The observations of the water masers (22 GHz) were carried out in 2008 with the VLA in its A configuration. The maser emission appears over a velocity range of $\sim$15 km s$^{-1}$ with the strongest maser feature at V(LSR)= 61.6 km s$^{-1}$ and weak maser components at 55.7 and 57.7 km s$^{-1}$ (Figure 1). From optical observations it has been estimated that the systemic velocity of IRAS18061−2505 is $v_{sys}$= +67 km s$^{-1}$. This indicates that almost all the masers features are blue-shifted with respect of the systemic velocity. The spectrum and maser positions are in agreement with the previous results presented by Gómez *et al.* (2008). Spatially, the masers appear located at one side of the central star, which is assumed to coincide with the peak of the radio continuum. In the right panel of Figure 1 we present a kinematical model of an expanding and rotating disk that fits the data qualitatively.

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