Cosmic Masers - from OH to H_0
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A Circumstellar Disk toward the High-mass Star-forming Region IRAS 23033+5951

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Abstract. We present water maser observations toward IRAS 23033+5951 carried out with the VLA-EVLA in the A configuration. In order to study the spatio-kinematical distribution of the water masers detected in the region, we made a simple geometrical and kinematical model based on the conical equation. We find that the water masers are tracing a rotating and contracting circumstellar disk of about 110 AU around a very young source of 18 $M_\odot$, which has not enough ionizing photons to be detected at centimeter wavelengths.

Keywords. High-mass stars formation: general — ISM:individual(H II regions, IRAS 23033+5951, water masers)

1. Introduction

Molecular outflows and circumstellar disks mark an important phase in the early evolution of low-mass star formation. In order to search for these structures in high-mass star formation regions, we have observed IRAS 23033+5951, which has a bolometric luminosity of 10^4 $L_\odot$ and is located at a distance of 3.5 kpc toward the Cepheus molecular cloud (Sridharan *et al.* 2002). IRAS 23033+5951 has been detected at millimeter and centimeter wavelengths, and a CO(2-1) bipolar outflow has been observed in the region in the northwest-southeast direction. (Beuther *et al.* 2004).

2. VLA-EVLA Observations

This high-mass star formation region was observed with the VLA-EVLA of the NRAO† (in the transition phase) in the A configuration during 2007 June 27 for five hours. Water maser and 1.3 cm continuum emission were simultaneously observed. The 3.6 cm continuum emission was also observed.

3. Results

Nine water maser spots are detected in the region, of which seven masers are clustered (M1) and two others that appear isolated (see Fig. 1). The maser emission is not spatially associated with any continuum source detected in the region. The water maser spectrum of M1 shows a structure of three peaks, similar to that observed toward several maser sources (e.g. S255, Cesaroni 1990; S140, Lekht *et al.* 1993) and interpreted as tracers of circumstellar disks. We also find that the masers in M1 are distributed, mainly, in two groups, where masers with redshifted velocity are located to the northeast, while that with blueshifted velocity are to the southwest. Moreover,

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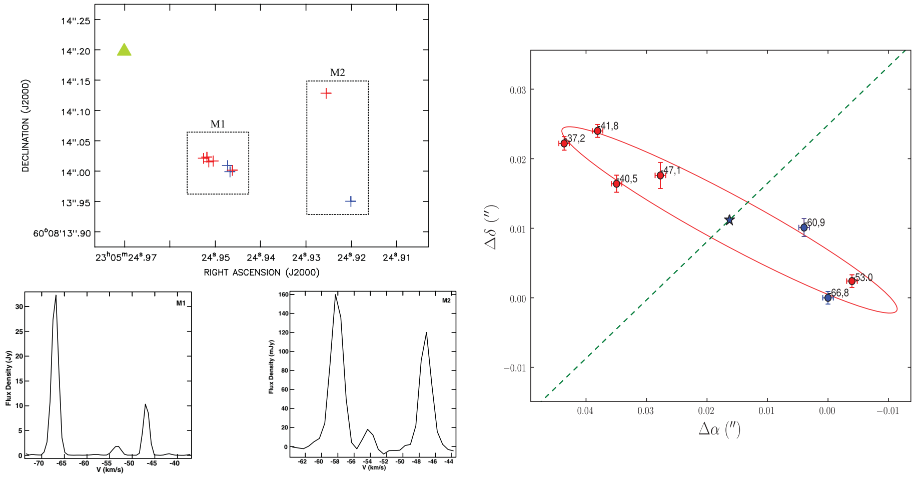

Figure 1. *Left)* Water maser emission toward IRAS 23033+5951. The two minor groupings in M1 are essentially the red-shifted emission to the northeast and the blue-shifted emission towards the southwest. A millimeter source (triangle), shifted about 0.25″ to the northeast, is observed in the region (Schnee & Carpenter 2009). *Right)* Fit of the water maser distribution. The star shows the position of the central source and the dotted line indicates the direction of the CO molecular outflow observed in the region.

the spatial distribution of the masers is almost perpendicular to the CO massive molecular outflow (northwest-southeast direction; e.g. Beuther *et al.* 2004). Based on these results, we suggest that the water maser emission in M1 is tracing a circumstellar disk.

In order to confirm the nature of the water masers in M1, we have built a simple geometrical and kinematic model. The spatial position of the water masers is fitted to the conical equation using the least-squares technique. The physical parameters of the fit indicate that the water masers are tracing an ellipse, which can be interpreted as part of a circumstellar disk of 0.05″ (projected on the plane of the sky; (see Fig. 1), corresponding to a linear radius of about 110 AU (assuming a distance of 3.5 kpc), with a position angle of 65 deg. In addition, based on a least-squares fit to the radial velocities of the maser spots, we find that the water masers are rotating and contracting with velocities of 17.2 and 0.7 km s^{-1}, respectively. Using these velocities, a mass of 17.8 $M_{\odot}$ is calculated for the central object.

Finally, we suggest that the central massive object, the circumstellar disk and the CO outflow observed in the region are forming a disk-YSO-outflow, similar to that found in low-mass stars. Finally, we speculate that the central object could be associated with a HC H II region, which has not enough ionizing photons to be detected at centimeter wavelengths.

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