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Water maser and radio continuum emission towards IRAS 23139+5939

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Abstract. We present simultaneous observations of continuum (3.5 and 1.3 cm) and water maser line emission (1.3 cm) carried out with the VLA-A toward the high-mass object IRAS 23139+5939. We detected two radio continuum sources at 3.5 cm separated by 0.″5 ($\sim$ 2400 AU), I23139 and I23139S. Based on the observed continuum flux density and the spectral index, we suggest that I23139 is a thermal radio jet associated with a high-mass YSO. On the other hand, based on the spatio-kinematical distribution of the water masers, together with the continuum emission information, we speculate that I23139S is also a jet source powering some of the masers detected in the region.

Keywords. ISM: jets and outflows, masers

1. Introduction

There is a deficit in the detection of thermal radio jets in high-mass YSOs with just a few clear cases (Cepheus A-HW2: Rodriguez *et al.* 1994, Curiel *et al.* 2006) and therefore it is unclear whether molecular outflows associated with high-mass objects also include at their base highly collimated thermal radio jets as low-mass stars do. In order to address this issue, we study the source IRAS 23139+5939, which is a high-mass star-forming region located near S157 at a distance of 4.8 kpc and has a luminosity of $\sim 2 \times 10^4$ $L_\odot$ (Sridharan *et al.* 2002).

2. Observations and results

The observations were made with the VLA of the National Radio Astronomy Observatory (NRAO)† in its A configuration. We observed simultaneously 1.3 cm continuum and water maser emission. The bandwidth for the line observations was centered at the frequency of the H_2O $6_{16} \rightarrow 5_{23}$ maser line with $V_{LSR} = -52.7$ km s^{-1}, covering from -73.1 to -32.3 km s^{-1} in velocity. The maser line and continuum data were reduced with standard techniques using the NRAO AIPS software package.

A radio continuum source, I23139, is only detected at 1.3 cm in the region, while two continuum sources, I23139 and I23139S, are detected at 3.5 cm (see Figure 1). The two

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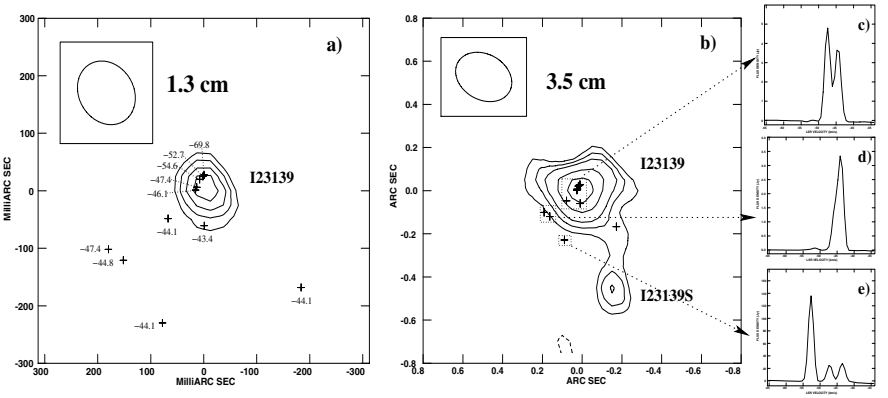

Figure 1. a) VLA 1.3 cm contour map toward IRAS 23139+5939. Contours are -4, -3, 3, 4, 5, and 6 times 140 μJy beam^{-1}, the rms noise of the map. The beam size is $0\farcs12 \times 0\farcs10$. The crosses show the positions of the water masers observed in the region. b) VLA contour map of the continuum emission at 3.5 cm toward IRAS 23139+5939. Contours are -4, -3, 3, 4, 5, 7, and 9 times 43 μJy beam^{-1}, the rms noise of the map. The beam size is $0\farcs30 \times 0\farcs19$. In both panels the angular offset is measured with respect to the I23139 peak position at 1.3cm. In order to be able to coincide both 1.3 and 3.5 cm peaks of I23139, we have applied an offset of 0.03" (northwest) to the position of I23139 at 3.5 cm, which is within the positional errors. c), d) and e) Spectra of the water masers enclosed in the box marked in panel b).

sources are separated by $0\farcs5$ ($\sim$ 2400 AU), with I23139S a new detection. No previous spectral index information for I23139 has been available. From the flux densities at 1.3 and 3.5 cm, we estimate a spectral index ($S_\nu \propto \nu^\alpha$) of 0.64 ± 0.36 for the source I23139, which is consistent with free-free emission from a thermal radio jet (Reynolds 1986).

We also find water maser emission toward IRAS 23139+5939, which is mainly distributed in two groups. One group, with seven masers, is spatially associated with I23139, while the other, with three masers, may be associated with I23139S. The precision of the relative positions between the radio continuum sources and the water masers is of the order of the 10 milliarcseconds. The water masers associated with I23139 trace an arc-like structure, while those associated with I23139S trace a linear structure. From the spatial and velocity distribution of the water masers, both groups of masers probably trace expanding motions. This appears to be consistent with Goddi *et al.* (2005), who measured proper motions of two water masers toward this region and found that the proper motions could be tracing the inner part of a conical outflow. In addition, I23139 is the best candidate for the driving source of the extended molecular outflow observed in the region. On the other hand, the second maser group seems to be pointing towards the source I23139S, which is located $0\farcs35$ to the southwest from the masers. This allows us to speculate that these masers could be associated with, and are pumped by, a jet of I23139S, although we do not rule out I23139, or even another undetected embedded source, as the pumping source.

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