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WATER VAPOR MASERS: A SIGNPOST FOR LOW MASS STAR FORMATION

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ABSTRACT

It is well known that water vapor maser emission at 22.2 GHz is associated with the earliest stages of both low- and high-mass star formation and it can be considered a reliable diagnostic of their evolutionary state. Bright Rimmed Clouds (BRCs) are clouds that have been compressed by an external ionization-shock front which focuses the neutral gas into compact globules. The boundary layer between the neutral gas and the gas ionized by the incident photons is often called "bright rim" but the clumps are sometimes classified also as speck globules or cometary globules depending on their appearance. Small globules with bright rims have been considered to be potential sites of star formation and have been studied in several individual regions. We present results from high resolution VLA observations searching for new candidates of recent star formation in bright-rimmed clouds/globules associated with IRAS point sources.

Key words : ISM:star formation — masers — globules

I. INTRODUCTION

Bright Rimmed Clouds (BRCs) are clouds that have been compressed by an external ionization-shock front which focuses the neutral gas into compact globules. The boundary layer between the neutral gas and the gas ionized by the incident photons is often called "bright rim" but the clumps are sometimes classified also as speck globules or cometary globules depending on their appearance. Small globules with bright rims have been considered to be potential sites of star formation. Evidence has been found for the presence of small clusters of embedded sources of intermediate and high- far-infrared luminosity ($L_{FIR} > 10^2$ $L_\odot$).

We present the first high resolution VLA observations of 20 of these BRCs performed with the VLA in 2005. We present the three detections obtained. The low detection rate seems to support the idea that BRCs produce mostly low-luminosity objects, for which maser emission is weak and episodic, and that the embedded sources are in a more advanced evolutionary phase than class 0 objects.

II. OBSERVATIONS

The observations were made with the VLA of the National Radio Astronomy Observatory (NRAO) in its B configuration during four runs in 2005. We observed water maser emission during 15 minutes on each target source. We used a bandwidth of 3.125 MHz with 127 channels of 24.4 KHz each, giving a velocity resolution of 0.33 km$\cdot$s^{-1}. We only used left circular polarization and the bandwidth was centered at the frequency of the H_2O $6_{16} \rightarrow 5_{23}$ maserline (rest frequency 22235.080 MHz), covering a velocity range of 40 km$\cdot$s^{-1}. The data were reduced with standard techniques using the NRAO AIPS software package. The resulting rms noise and beam size are 0.9 mJy beam^{-1} and 0.45" x 0.3", respectively.

Only three sources were detected, all towards the HII region IC 1396 also known as S131, in the Cep OB2 association at a distance of 750pc. IC 1396N is an extended HII region excited by the O6 star HD 206267 which also drives an energetic outflow. This region is associated with OH and H_2O maser emission (Slysh et al. 1999; Migenes et al. 1999; Migenes et al. 2006) in addition to other molecular species. In all cases the detection consisted on a single maser spot spread over a few chanels.

III. DISCUSSION

(a) BRC 36

The IRAS source associated with this globule has a luminosity of 110 $L_\odot$ and FIR-colours typical of protostellar candidates or precursors to UCHII regions. It is located in the tail of the globule, rather than in its head, very near the bright rim. Single-dish monitoring observations (Valdettaro et al. 2005) show very variable H_2O maser emission, which is common in low-luminosity sources.

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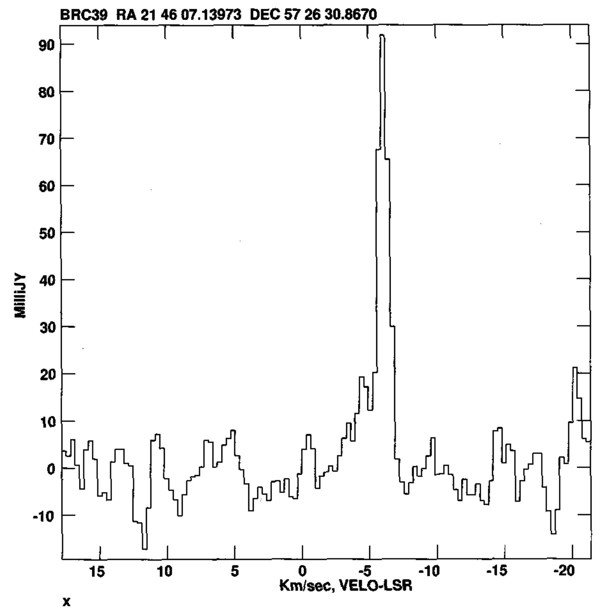

Fig. 1.— VLA-B spectrum of the water maser emission towards BRC 39. The spectrum is obtained integrating over the whole emission area of all velocity channels. The clouds systematic velocity is -1.7 km$\cdot$s^{-1}. Maser is detected at -6.1 km$\cdot$s^{-1}.

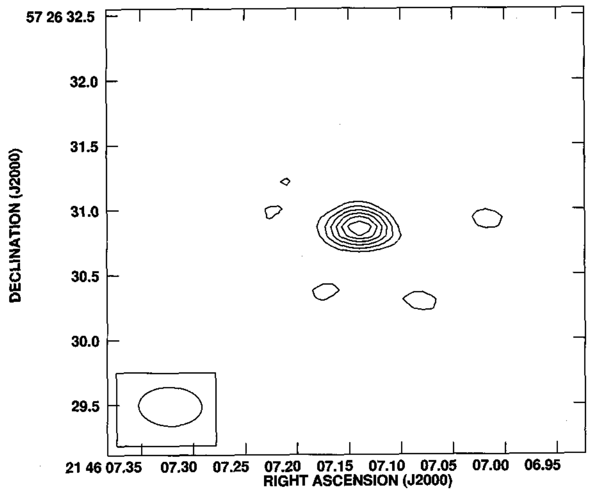

Fig. 2.— Integrated intensity contour map of the maser emission in BRC 39. The integration is over the velocity-interval -6.7 to -5.1 km$\cdot$s^{-1}. The contour levels are -5, -3, 3, 5, 7, 9, 11, 13 times 32 mJy$\cdot$beam^{-1}, the rms of the map. The beam (0.49" x 0.30") is shown in the lower left-hand corner. The peak emission of the water maser is detected at -6.1 km$\cdot$s^{-1}.

(b) BRC 37

The globule has a cometary rim morphology and hosts an embedded IRAS source with a luminosity of 110 $L_{\odot}$ (Sugitani et al. 1991), classified as a Class 0 like object by Sugitani et el (2000) on the basis of the ratio L_{bol}/L_{sub}. Duvert et al (1990) detected a bipolar outflow with a 20" separation between the red and blue lobes and a N-S orientation.

(c) BRC 39

The globule has a tightly curved rim morphology and hosts an embedded IRAS source with a luminosity of 96 $L_{\odot}$ (Sugitani et al. 1991). The VLA position of the H_2O maser is quite close to that of the IRAS source, indicating that the latter is the exciting source. Froebrich et al. (2005) found in the optical field a new giant flow emerging from the embedded IRAS source. Figures 1 and 2 show the spectrum and map, respectively, for this source first time detection.

IV. CONCLUSIONS

A sensitive search for water maser emission from 20 BRCs of the northern hemisphere carried out at the VLA has yielded three detections, only one of which is the first time. This results put on firmer ground the initial findings of less sensitive, single-dish studies of Valdettaro et al. (2005, 2007). The low detection rate for water vapor maser emission in BRCs, is not completely due to the sensitivity of the observations, but it could also be due to lower FIR flux from the YSO. The dust strongly contributes to the IRAS measured flux from the YSO. The much lower intrinsic FIR flux of the YSO would suggest that BRCs are sites of low-mass-star formation. BRCs seem to produce mostly low-luminosity Class I objects, which are presently in a more advance evolutionary phase than class 0 sources, for which the frequency of occurrence of maser emission is low and highly episodic. The high resolution positions of the water vapor maser emission will help us identify their exciting source.

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