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H_2O maser emission from bright rimmed globules

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Abstract. We report the results of a multi-epoch campaign of water maser observations of Bright Rimmed Globules (BRCs) associated with IRAS point sources. We have observed all of the 44 BRCs listed by Sugitani et al. (1991), visible in the northern hemisphere. With the exception of one globule, IC 1396N, we did not detect water maser emission in any of the targets. This negative result is somewhat surprising, if the suggestion of induced massive star formation in BRCs is correct. In contrast, we believe that newly formed stars inside BRCs tend to be of low luminosity and the occurrence of H_2O maser emission is rare, episodic, and highly variable.

1. Introduction

We report the results of a multi-epoch survey of water maser observations at 22.2 GHz with the Medicina radiotelescope from BRCs associated with IRAS point sources. BRCs have been considered very promising sites of star formation, triggered by the compression of ionization and shock fronts from nearby HII regions (e.g., Sugitani et al. 1989). In particular, evidence has been found for the presence of small clusters of embedded sources of intermediate- and high-far-infrared luminosity ($L_{\rm FIR} \gtrsim 10^2$ $L_\odot$). Also, the ratios of the lumimosity of the IRAS sources to the globule mass (as measured from molecular line emission) are much higher than those found in isolated dark globules (Sugitani et al. 2000). These properties suggest that star formation may proceed in a different mode in globules associated with bright rims than in more quiescent ones, which spawn low-luminosity objects ($L_{\rm FIR} \lesssim 10^2$ $L_\odot$).

Our aim is to test this suggestion by using water masers as a reliable diagnostic of newly formed massive objects. For our study, we have observed at least twice all of the 44 BRCs listed by Sugitani et al. (1991), visible in the northern hemisphere. With the exception of one globule, IC 1396N located in S131, we did not detect water maser emission in any of the targets. Since the frequency of occurrence of water masers is *higher* towards bright IRAS sources, our negative result is somewhat surprising, if the suggestion of induced high-mass star formation is indeed correct. We present detailed observations of the long-term emission properties of the maser found in IC 1396N, and we discuss possible interpretations of the absence of H_2O maser emission in BRCs.

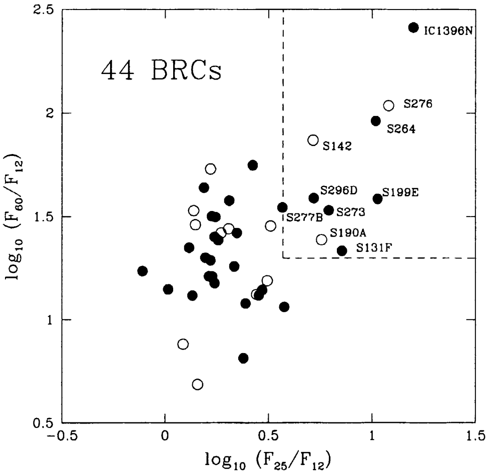

Figure 1. Location of the 44 BRCs in the IRAS color-color diagram. Solid dots represent sources with good IRAS fluxes, while upper limits at 12 μm are shown as empty circles. The dashed lines delimit the boundaries of candidate UCHII regions.

2. Observations and Results

The observations were performed with the Medicina 32-m antenna in two dedicated sessions in January 1993 and December 2000. A number of sources have been observed in different periods during the course of other projects. The telescope HPBW at 22.2 GHz is 1.9′. The pointing accuracy is better than $\sim 25''$. Typical integrations of 5 min on-source were performed. Water maser emission was found only toward IC 1396N (Sugitani's cloud N. 38). Since we have monitored the emission from this source for about 12 years, below we present the detailed long-term properties.

The location of the 44 BRCs in the [60-12] vs [25-12] color-color diagram is shown in figure 1. We note that 10 BRCs have colors typical of UCHII regions (Wood & Churchwell 1989), IC 1396N having the most extreme values. The majority of the IRAS sources in BRCs, however, fall outside the box, and have color typical of protostellar candidates or precursors to UCHII regions.

3. The H_2O Maser in IC 1396N

IC 1396 is a well known extended HII region (S131) located near the Cep OB2 association. The region is ionized by the star HD 206267 (O6.5V), the brightest member of of the young cluster Trumpler 37, which contains about 20 O stars, at a distance of 750 pc (Weikard et al. 1996). IC1396N is a bright rimmed globule in the northern part of the region. It presents a striking cometary structure and contains the source IRAS 21391+5802, with a luminosity of 340 $L_\odot$, a massive bipolar molecular outflow, and an H_2O maser. a group of very red near infrared sources is also detected (Codella et al. 2001). The Medicina 22.2 GHz observations started in March 1989. The source has been monitored regularly starting in 1993, and we have obtained 36 spectra. During the patrol, the maser has always been active. The velocity-time contour plot of the emission is shown in Figure 2. The main properties of the maser emission can be summarized as follows.

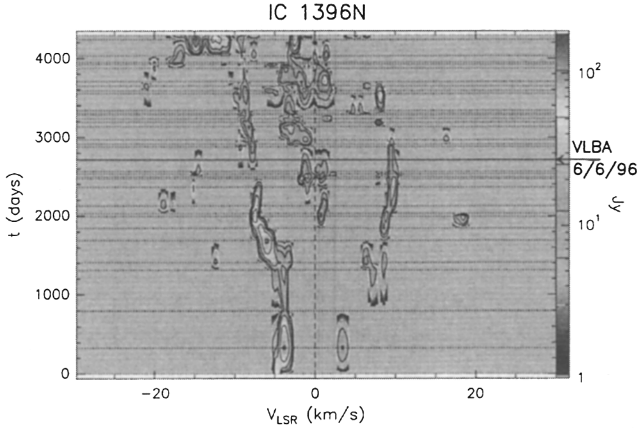

Figure 2. Color plot and contour map of the maser line flux density as a function of velocity and time. The dotted horizontal lines correspond to the dates of the observed spectra. The vertical dashed line indicates the systemic velocity of the associated molecular cloud. The arrow indicates the epoch of the VLBA observations by Slysh et al.(1999).

The H_2O maser is active at all times, with emission extending from $V_{LSR} \sim -20$ km s^{-1} to $V_{LSR} \sim +20$ km s^{-1}. The main features occur at velocities around -10 km s^{-1}. A steady component is not present, and the maser emission appears to arise from individual events that last about 2 yr, scattered over a large velocity interval. As shown in Figure 3, the integrated flux emission is low and constant, typically around 100 Jy km s^{-1}. Only at the end of our patrol, a marked increase occurred at a level of $\sim$400 Jy km s^{-1}. The large flare has $F_{peak} \simeq$200 Jy at $V_{LSR} = -15$ km s^{-1}.

The global pattern of the maser in IC 1396N is similar to that described by Slysh et al.(1999) in their single-epoch VLBA observations. They interpreted the blue- and red-shifted high velocity features as arising from the molecular outflow, whereas the low-velocity features would originate in a Keplerian disk. However, as shown in Fig. 2, some global velocity drifts are clearly present, and we believe that they trace a global acceleration of the molecular outflow, rather than motion in a disk. Finally, we note that the integrated maser emission is not highly variable, given the far-infrared luminosity of the exciting YSO. IC 1396N does not appear to follow the trend of high water maser variability for low-luminosity sources found in the sample for the variability study (see the other contribution in this volume by Valdettaro et al.).

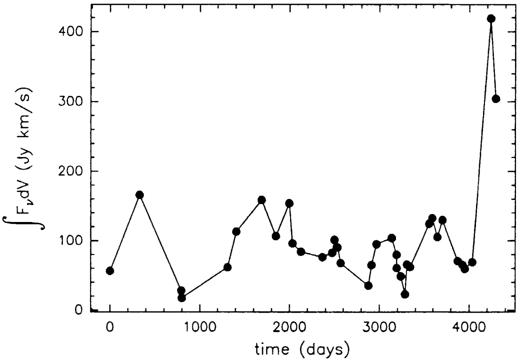

Figure 3. Integral of the flux density over the observed velocity range as a function of time

4. Discussion

With the exception of IC 1396N, we have not detected water emission in any of the 44 BRCs which are believed to be sites of intermediate- to high-mass star formation, based on the luminosity of the associated IRAS sources (10^2 to 10^4 $L_\odot$). This negative result can be partly explained by the fact that the majority of the IRAS sources have far-infrared colors typical of sources (see Fig. 1) that have very low H_2O maser detection rates (e.g., Palla et al. 1991).

The lack of maser emission in 9 of the 10 sources with far-infrared colors typical of UCHII regions is more surprising, since the detection rate for such sources is typically high. A possible explanation is that in most cases the observed IRAS luminosity is not due to the embedded YSO, but represents the emission from heated dust in the bright rim that surrounds the dark cloud. Contrary to the conclusions of Sugitani and collaborators, we believe that star formation within BRCs produces mostly low-luminosity objects for which the frequency of occurrence of maser emission is low, episodic and highly variable (e.g., Claussen et al. 1996).

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