Astron. Astrophys. 327, 755–757 (1997)

ASTRONOMY
AND
ASTROPHYSICS

Research Note

Search for H_2O maser emission from high-latitude IRAS sources

F. Palla[1], **C. Codella**[2], **R. Valdettaro**[1], **and C. Baffa**[1]

[1] Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, I-50125 Firenze, Italy (e-mail: palla@arcetri.astro.it)
[2] Max Planck Institut für Radioastronomie, Auf dem Hügel 69, D-53121 Bonn, Germany

Received 2 January 1997 / Accepted 4 June 1997

Abstract. A high-sensitivity search for water maser emission at 22.2 GHz has been performed on a sample of 91 IRAS point sources at high-latitudes[1]. The aim of the survey is to verify if these clouds are capable of star formation as indicated by the presence of water masers. The sample is based on the recent work of Magnani et al. (1995) who have identified 192 infrared objects from the IRAS Faint Source Survey possibly associated with translucent clouds at galactic latitudes $|b| \geq 30°$. These IRAS sources have far-infrared colours typical of young stellar objects and pre-main-sequence stars and thus provide a starting list for further studies about their actual nature. H_2O maser emission is a good diagnostic of the presence of dense gas and of recent star formation. We did not find water maser emission at a level of 0.2-0.5 Jy (3σ) in any of the 91 objects. The negative result indicates that these high-latitude sources do not represent potential sites of star formation, consistent with the fact that most high-latitude molecular clouds do not appear gravitationally bound.

Key words: masers – stars: formation – ISM: clouds – galaxies: starburst

1. Introduction

Since their discovery by Magnani et al. (1985, hereafter MBM), molecular clouds at high latitudes ($|b| \geq 30°$) have received considerable attention. The majority of high-latitude clouds are characterized by low average volume densities ($n \sim 100\,\mathrm{cm}^{-3}$), masses (in the range 10 to 100 $M_\odot$), and have visual extinctions between 1 and 5 magnitudes (van Dishoeck et al. 1991). A catalog of all the presently known clouds has been compiled by Magnani et al. (1996). From their analysis, Magnani et al. (1996) conclude that the majority of the high-latitude clouds are local objects (the mean distance of the sample is 150 pc), possibly located at the near edge of the Local Bubble. Their ensemble should contribute to 10% to 20% of the total molecular gas budget of the local ISM.

Multitransition observations of several molecular species indicate the existence of small cores with densities in excess of $\sim 10^3$ cm^{-3} (Turner et al. 1992; Reach et al. 1995). These conditions are very similar to those observed in dark clouds at low galactic latitudes which are well known sites of low-mass star formation. The question has naturally raised whether the translucent molecular clouds share this property with standard dark clouds.

There have been two recent attempts to answer this question. In the first one, Magnani et al. (1995, hereafter MCBB) have compiled a list of all possible star forming sites based on data from the IRAS Faint Source Survey (Moshir et al. 1989). By using far-infrared colours typical of pre-main-sequence stars and young stellar objects (YSOs), they identified 127 candidate sources not associated with regions of known molecular clouds (hereafter referred to as sample A), plus another 65 sources with less reliability (sample B). MCBB estimate that the star formation efficiency in high-latitude clouds would be at most of order of $\sim$1%, assuming that all the faint IRAS sources were genuine young stars of solar mass. In a second paper, Caillault et al. (1995) have used X-ray emission as a diagnostic of the nature of the sources embedded in some high-latitude clouds. A search through the *Einstein* IPC X-ray database yielded negative results, with the exception of one star located however in a Lynds dark cloud (L1457, MBM12-1). The result was considered not too surprising, and Caillault et al. (1995) concluded that the translucent clouds have yet to reveal any evidence of star formation.

Guided by the MCBB paper, we have set out an experiment aimed at detecting 22.2 GHz water maser emission in a sample of their sources. The presence of H_2O maser emission reveals

Send offprint requests to: F. Palla

[1] Tables 1 and 2 are available in electronic form at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsweb.u-strasbg.fr/Abstract.html

dense gas (with densities in excess of 10^8 cm^{-3}) in star forming regions. It is well known that H_2O masers are associated with objects in the earliest evolutionary phases independent of their luminosity/mass. Several surveys towards HII regions (Codella et al. 1994; Codella & Palla 1995), IRAS sources in the inner and outer Galaxy (Wouterloot et al. 1993, 1995), CO outflow sources (Tofani et al. 1995) and low-mass stars (Wilking et al. 1994) have greatly expanded our knowledge of the occurrence of the maser phenomenon. The detection of water masers can therefore be considered a secure identifying criterion even in the case of the infrared sources embedded within high-latitude clouds.

Previous searches for water masers at high-latitudes have yielded only upper limits to the H_2O flux. In a survey of 1409 IRAS sources selected using the Emerson (1987) colour criteria for YSOs, Palumbo et al. (1994) and Codella et al.(1995) have observed 80 sources with $|b| \geq 20°$ with an average rms of 2 Jy. Maser emission was found only in two sources within known star forming regions (Orion and HH 7-11).

It is well known that the luminosity of the maser source (L_{H_2O}) scales with the far-infrared (FIR) luminosity of the associated IRAS source, and the typical ratio of the luminosities is of order $L_{H_2O}/L_{FIR} \sim 10^{-10}$-$10^{-9}$ (e.g. Palagi et al. 1993). Since the average luminosity of the IRAS sources in the MCBB sample is $L_{FIR} \sim 0.1\ L_\odot$, assuming a distance of 150 pc, the expected H_2O luminosity is about $L_{H_2O} \sim 10^{-10}\ L_\odot$, or a peak flux of ~ 0.3 Jy for isotropic emission and a linewidth of 1 km s^{-1}. However, the flux could be quite smaller than the isotropic value and this calls for high sensitivity observations. In this paper, we report on the results of such a survey performed with the MPIfR Effelsberg (Bonn, Germany) 100-m radiotelescope.

2. Observations and results

We have observed 53 IRAS sources listed by MCBB in sample A with a declination greater than $-20°$. In addition, we have selected 3 X-ray sources from the list of Caillault et al. (1995) which have probably galactic stellar counterparts. Table 1 gives the sources of sample A with their identification number, the IRAS name, the equatorial (1950) coordinates, and the observed rms (1σ)in the H_2O line. The three sources from Caillault et al. (1995) are labelled by their MBM number. We have also chosen 35 sources from sample B with the same characteristics. Their properties are listed in Table 2. Thus, our final lists contain a total of 91 sources.

The observations were made with the 100-m antenna during several runs in August and September 1995 and September 1996. At the frequency of the water maser line ($6_{16} \rightarrow 5_{23}$; 22235.07985 MHz) the HPBW is 40″. The system temperature ranged from 70 K to 140 K depending on the weather conditions. The intensity scale of the spectra was calibrated on the continuum sources NGC7027 and 3C286, using the values given by Baars et al. (1977) and Ott et al. (1994). The calibration accounted for the dependence of the gain on the elevation. The flux density uncertainties are of the order of 20%. The pointing accuracy was better than 10″, corresponding to a point source

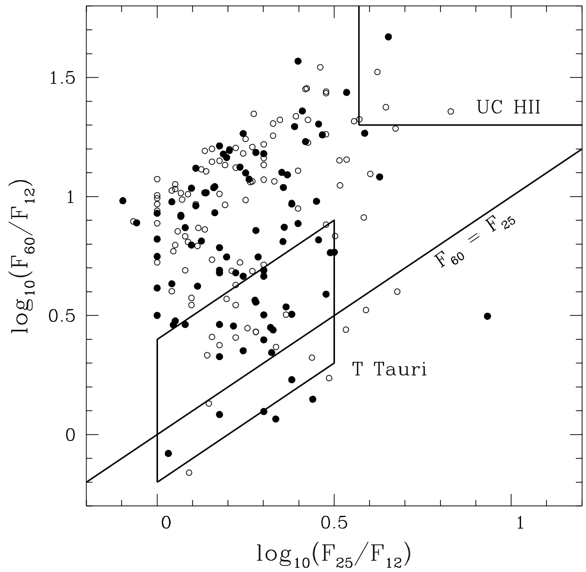

Fig. 1. [25-12] vs. [60-12] colour distribution of the 192 IRAS point sources associated with translucent clouds from MCBB (see text). The 91 sources observed at 22.2 GHz are shown as filled circles. The boxes delimit the colours of T Tauri stars (Emerson 1987) and ultracompact (UC) HII regions (Wood & Churchwell 1989).

sensitivity uncertainty of about 15%. The observations were obtained in total power mode using position switching, with an integration time of about 20 minutes on source for those listed in Table 1 and of 3 minutes for the sources in Table 2. Spectral information was obtained with a 1024-channel three-level autocorrelation spectrometer, providing 0.330 km s^{-1} sampling and a total velocity coverage of ± 160 km s^{-1} across a 25 MHz bandpass. The average detection level (3σ) is 0.18 Jy for sample A and 0.51 Jy for sample B.

We did not observe maser emission features in any of our targets. The overall negative result of the survey is not totally unexpected for a variety of reasons. The first one is that the IRAS sources identified by MCBB are very weak. Studies of water masers associated with low-mass stars have shown that the frequency of occurrence decreases with the infrared luminosity of a source and that the emission is highly variable, sometime reaching two orders of magnitude in a period of several months (Persi et al. (1994), Codella et al. (1996), Wilking et al. (1994) and Claussen et al. (1996)). Perhaps more importantly, there is still no direct evidence that the faint IRAS sources at high-latitudes are indeed associated with molecular gas and/or with YSOs. In fact, the translucent high-latitude clouds are often identified with the molecular component of the IRAS 100μm cirrus and it is very likely that the majority of the IRAS sources observed by us are infrared cirrus clumps associated with atomic and not molecular hydrogen. In support of the latter possibility, we mention the case of the source MCBB77. In the course of the first run, we had tentatively detected a weak emission feature which motivated us to search for the presence of molecular gas in the region and to confirm the association of the IRAS source with a new star forming site. We have observed several molecular transitions using the 100-m MPIfR and the 30-m Pico Veleta antennas, including ^{12}CO ($J = 1 \rightarrow 0$), NH_3(1,1), NH_3(2,2), but did not detect emission down to about 0.1 K in CO and 0.07 K in ammonia. Similarly, continuum observations at 1.3 millimeter did not show the presence of cold dust in the region. Subsequent observations at 22 GHz did not confirm the occurrence of water maser emission. These negative results indicate that the presence of a faint IRAS source is not necessarily an indication of ongoing star formation.

3. Discussion

Evidence for star formation in high-latitude clouds has been found in half a dozen regions and about twelve T Tauri and Herbig Ae/Be stars and YSOs candidates have been identified (see MCBB). However, these clouds are all Lynds clouds and therefore not primarily translucent. Martín & Kun (1996) have identified spectroscopically four new T Tauri stars among 100 Hα candidates discovered by Kun (1992). Since these stars are associated with the dark cloud L134, the authors conclude that no translucent cloud has yet proved to form low-mass stars. In our study, we have observed two isolated T Tauri stars, LkHα 264 and St 202, and one source in MBM12, probably the best studied high-latitude cloud. None of these sources shows maser emission.

What can we say then about the star formation efficiency of high-latitude clouds? MCBB estimate an upper limit of a few tenths of one percent assuming that all the candidates in their sample are indeed young stars of one solar mass. This value is lower than the typical efficiency of few percent determined in low-mass SFRs. On the other hand, in the two dense cores studied by Reach et al. (1995) the derived star formation rate is larger than that in the solar neighbourhood, suggesting that such clouds could be a significant birth site for low-mass stars. It is worth noting that the distribution in the colour-colour plot of the sources associated with high-latitude clouds (see Fig. 1) is indistinguishable from that of the IRAS sources found in the dense molecular cores of nearby star forming regions (see Fig. 3 of Codella & Palla 1995). These sources are the best examples of protostellar candidates: the average FIR luminosity (1 to 10 $L_\odot$) is higher than that of the present sample ($\ll$1 $L_\odot$) and the maser detection rate is correspondingly higher ($\sim$10%). Our negative results indicate that, even accounting for the high degree of variability, water maser emission is a rare phenomenon in high-latitude clouds and that the efficiency of star formation in these regions could be much lower than the suggested value of a few tenths of a percent. This is consistent with the fact that most high-latitude clouds do not appear to be gravitationally bound and in the process of forming stars.

References

Baars, J.W.M., Genzel, R., Pauliny-Toth, I. I. K., Witzel, A., 1977, A&A, 61, 99
Caillault J.-P., Magnani L., Fryer C., 1995, ApJ, 441, 261
Claussen, M.J., Wilking, B.A., Benson, P.J., Wootten, A., Myers, P.C., Terebey, S. 1996, ApJS, 106, 111
Codella, C., Palla, F., 1995, A&A, 302, 528
Codella, C., Felli, M., Natale, V., 1996, A&A, 311, 971
Codella, C., Felli, M., Natale, V., Palagi, F., Palla, F. 1994, A&A, 291, 261
Codella, C., Palumbo, G.G.C., Pareschi, G., Scappini, F., Caselli, P., Attolini, M.R., 1995 MNRAS, 276, 57
Emerson, J.P., 1987, in Proc. IAU symp. on Star Forming Regions, eds. M. Peimbert & J. Jugaku (Kluwer: Dordrecht), p.19
Kun, M. 1992, A&AS, 92, 875
Magnani L., Blitz L., Mundy L., 1985, ApJ, 295, 402 (MBM)
Magnani, L., Caillault, J.-P., Buchalter, A., Beichman, C.A., 1995, ApJS, 96, 159 (MCBB)
Magnani, L., Hartmann, D., Speck, B.G. 1996, ApJS, 106, 447
Martín, E.L., Kun, M. 1996, A&AS, 116, 463
Moshir M. et al., 1989, IRAS Faint Source Catalog Explanatory Supplement, IPAC preprint 44
Ott, M., Witzel, A., Quirrenbach, A., et al., 1994, A&A, 284, 331
Palagi, F., Cesaroni, R., Comoretto, G., Felli, M., Natale, V., 1993 A&AS, 101, 153
Palumbo, G.G.C., Scappini, F., Pareschi, G., Codella, C., Caselli, P., Attolini, M.R. 1994, MNRAS, 266, 123
Persi, P., Palagi, F., Felli, M., 1994, A&A, 291, 577
Reach, W.T., Pound, M.W., Wilner, D.J., Lee, Y., 1995, ApJ, 441, 244
Tofani, G., Felli, M., Taylor, G.B., Hunter, T.R., 1995, A&AS, 112, 299
Turner, B.E., Xu, L., Rickard, L.-J., 1992, ApJ, 391, 158
van Dishoeck, E. F., Black, J.H., Phillips, T.G., Gredel, R., 1991, ApJ, 366, 141
Wilking, B.A., Claussen, M.J., Benson, P.J., et al., 1994, ApJ, 431, L119
Wood, D.O.S. & Churchwell, E. 1989, ApJ, 340, 265
Wouterloot, J.G.A., Brand, J., Fiegle, K., 1993, A&AS, 98, 589
Wouterloot, J.G.A., Fiegle, K. Brand, J., Winnewisser, G., 1995, A&A, 301, 236

This article was processed by the author using Springer-Verlag LaTeX A&A style file *L-AA* version 3.