Astrophysical Masers and their Environments
Proceedings IAU Symposium No. 242, 2007
J.M. Chapman & W.A. Baan, eds.

doi:10.1017/S1743921307013051

Millimetre wavelength methanol masers survey towards massive star forming regions

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Abstract. We present the results of a mm wavelength methanol maser survey towards massive star forming regions. We have carried out Class II methanol maser observations at 86.6 GHz, 86.9 GHz and 107.0 GHz, simultaneously, using the Nobeyama 45 m telescope. We selected 108 6.7 GHz methanol maser sources with declinations above −25 degrees and fluxes above 20 Jy. The detection limit of maser observations was ∼3 Jy. Of the 93 sources surveyed so far, we detected methanol emission in 25 sources (27%) and "maser" emission in nine sources (10%), of which thre "maser" sources are new detections. The detection rate for maser emission is about half that of a survey of the southern sky (Caswell et al. 2000). There is a correlation between the maser flux of 107 GHz and 6.7 GHz/12 GHz emission, but no correlation with the "thermal" (non maser) emission. From results of other molecular line observations, we found that the sources with methanol emission show higher gas temperatures and twice the detection rate of SiO emission. This may suggest that dust evaporation and destruction by shock are responsible for the high abundance of methanol molecules, one of the required physical conditions for maser emission.

Keywords. masers, surveys, ISM: molecules, radio lines: ISM, stars: formation

1. Introduction

It is known that class II methanol maser emission is a good tracer for the earliest stages of massive star formation. Extensive surveys of methanol maser emission at 6.7 GHz have been carried out in the southern hemisphere (Val'tts *et al.* 1999; Caswell *et al.* 2000). Caswell *et al.* (2000) detected maser emission at 107 GHz in 22 of 84 sources (26%) and detected 157 GHz emission from only four sources (5%). However, no systematic surveys have been carried out in the northern hemisphere: Minier & Booth (2002) have surveyed a limited sample of 23 maser sources in the northern hemisphere. They detected maser emission at 107 GHz from six sources (26%) and at 86.6 GHz from two sources (9%). In this paper, we present the results of a systematic millimetre methanol maser survey in the northern hemisphere.

2. Observations

Methanol emission of 7_2-6_3 A^- at 86.6 GHz, 7_2-6_3 A^+ at 86.9 GHz and 3_1-4_0 A^+ at 107.0 GHz were simultaneously observed using the 45 m telescope of the Nobeyama Radio Observatory. In addition, we have made observations of SiO ($J=2$–1, $v=0$) and $H^{13}CO^+$ ($J=1$–0) lines simultaneously, to distinguish between maser and non-maser emssion by comparing the methanol data with thermal emission lines. We selected 108 sources of 6.7 GHz methanol maser sources with declinations > -25 degrees and fluxes > 20 Jy from the source list of Szymczak *et al.* (2000), Menten (1991) and others. We used two 3 mm SIS receivers. The backend was a bank of eight acousto-optical spectrometers with 37 kHz resolution (0.10 km s^{-1} at 107 GHz). The detection limit of our maser survey was $\sim$3 Jy, the same as for the southern survey by Caswell *et al.* (2000).

3. Results and discussion

So far we have surveyed 93 sources, with methanol emission detected in 25 sources (27%) and "maser" emission in nine sources (10%). Three "maser" sources, 18556+0136, 19110+1045 and 19216+1429, are new discoveries. Including previously known maser sources in the area we still need to survey, a total of 13 maser sources (14%) have been detected. Our detection rate of maser emission is about half that of the southern sky survey (Caswell *et al.* 2000). However, $H^{13}CO^+$ emission has been detected in only 48 sources (52%) in our sample, because of uncertainties in the 6.7 GHz maser positions and the smaller sizes of the emitting regions. If we consider only sources with detections of $H^{13}CO^+$ emission, then the detection rate for maser emission is 25%, the same as for the southern hemisphere sample.

We have compared the maser flux at 107 GHz and at 6.7 GHz/12 GHz including the southern survey data. The maser flux at 107 GHz is about (1–10)% of the flux at 6.7 GHz, and there is a correlation between the maser flux at 107 GHz and at 6.7 GHz and also at 12 GHz. However there is no correlation with the "thermal" (non maser) emission. We found that sources with methanol emission show higher gas temperature (determined from our NH_3 observations) and have twice the detection rate of SiO emission. In addition, sources with maser emission have wider thermal linewidths from SiO than from $H^{13}CO^+$. This may suggest that dust evaporation and destruction by shocks from outflows is responsible for the high abundance of methanol molecules, one of the required physical conditions of maser emission.

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