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The 44 GHz methanol maser line in massive star forming regions

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Abstract. We present the results of recent surveys in the 44 GHz methanol maser line toward regions of massive star formation using the Haystack 37 m telescope and the VLA. We discuss a possible shock origin of this maser line and present evidence for variability from multi-epoch observations of selected sources.

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

1. Introduction

The CH_3OH $7_0 - 6_1$ A^+ line at a rest frequency of 44.069430 GHz is wide spread in regions of massive star formation (e.g. Haschick *et al.* 1990, ApJ 354, 556), however prior to our work (e.g. Kurtz *et al.* 2004, ApJS 155, 149), interferometric observations of this line were scarce. We are conducting single dish and VLA surveys in this line with the goal of establishing this maser as a probe for massive star formation research.

2. A catalogue of 44 GHz methanol masers in massive star forming regions

We used the VLA to survey 44 massive star-forming regions; 37 fields showed maser emission. Thirty-one sources were also observed in the 23 GHz $9_2 - 10_1$ A^+ methanol line, only two fields showed maser emission in this line. Although the 44 GHz line is a class I methanol maser, we find a large number of sources in relatively close association with H II regions and water masers: In a subsample of 22 fields which contain both 44 GHz maser emission and compact HII regions, the median projected distance between masers and ionized gas is 0.2 pc.

Several sources, most notably IRAS 20126 + 4104, G31.41 + 0.31, G34.26 + 0.15, and DR21(OH), show strong evidence for a correlation between 44 GHz masers and shocked molecular gas, supporting the interpretation that molecular outflows give rise to class I maser emission (Figure 1).

We provide maser positions with arcsecond accuracy that not only locate the masers with respect to other star formation phenomena, but also provide, for the stronger masers, phase referencing and pointing sources that can be used for observations in the 7 mm band of massive star forming regions.

3. Haystack observations of 44 GHz methanol masers towards massive protostars

Based on the results presented above we are continuing our 44 GHz CH_3OH masers survey. The sources observed in Kurtz *et al.* (2004) mostly contained UC HII regions, and

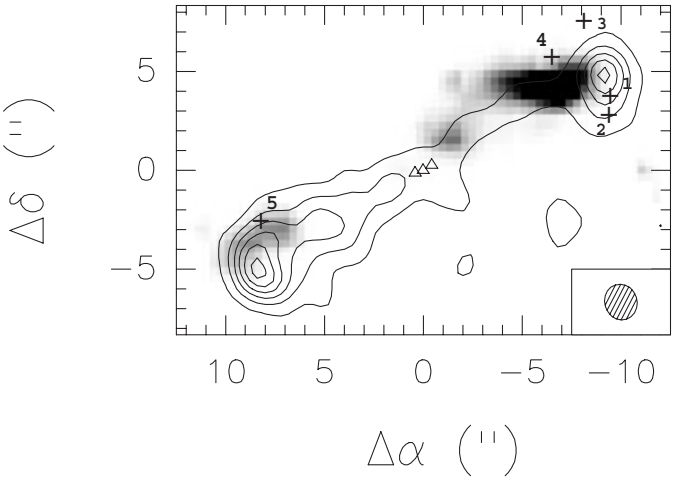

Figure 1. IRAS 20126+4104. Contours show SiO (2-1) emission, gray-scale shows H_2 emission, triangles indicate water masers while numbered crosses are 44 GHz methanol masers. The methanol masers appear to trace the edge of the shocked gas seen in H_2 (see Kurtz *et al.* 2004).

we are now surveying an earlier phase of massive star forming regions, containing high luminosity sources without detectable radio continuum. Our objective is to investigate whether the properties of the 44 GHz maser line will change with evolutionary phase. Since this maser line is a good tracer of molecular flows (see above) we expect to learn about the frequency of occurence and properties of molecular flows in a phase of massive star formation prior to that of UCHII regions. We will contrast the characteristics of the massive protostellar sample with the results from the UC HII region sample presented above.

To prepare for interferometric observations we have observed a sample of massive protostellar candidates with the 37m Haystack telescope (beamwidth at 44 GHz is 46″). We detect strong emission in 12 sources, and weak emission in many others. The typical rms noise of the Haystack spectra is 1 Jy. As a few deep integrations showed, most of the weak candidates are likely to be real detections when observed at lower rms noise levels. Thus, a very high detection rate is expected with the VLA given that the theoretical VLA rms noise in 10 min on-source observations is 0.025Jy/b. The VLA observations of the full sample are scheduled for spring 2007.

The Haystack data also allows us to investigate whether the CH_3OH 44 GHz transition is variable. Preliminary analysis indicates that this is the case for most sources.

Acknowledgements

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