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METHANOL SURVEY TOWARDS STAR-FORMING SITES: MORPHOLOGY OF THE 12.2 AND 6.7 GHz SPECTRA

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Abstract. We discuss the results of a 12.2 GHz methanol maser survey done with the Toruń 32 m radio telescope. We examined 261 star-forming sites, known as containing 6.7 GHz maser emission sources. The survey resulted in 49 sources with 6.7 GHz maser line detection, 21 of them were previously unknown. We compare basic spectral line properties at 12.2 and 6.7 GHz transitions and discuss the morphological connections between spectral shapes at both frequencies. In a few cases absorption features are accompanied by emission in the other monitored frequency, at the same velocity.

Key words: masers – stars: formation – ISM: molecules – radio lines: ISM — H II regions

1. INTRODUCTION

The 12.2 GHz maser emission of CH_3OH was first observed by Batrla et al. (1987); the 6.7 GHz methanol transition was discovered by Menten (1991) who designated two groups of 6.7 GHz methanol maser sources – class I and class II. The first group is related to outflow shocks (Plambeck & Menten 1990). The class II is usually observed towards Ultra Compact H II regions. This class provides excellent information on the physics of the star-forming sites. The 12.2 GHz emission is mainly bound up with the class II sources.

The presented experiment allows one to compare the 6.7 GHz and 12.2 GHz spectral line properties. In this paper we put particular stress on the presentation of the morphological connections between 12.2 and 6.7 GHz emission.

2. OBSERVATIONS AND RESULTS

The observations were carried out in 2002 between June 24 and August 15 with the 32 m Toruń radio telescope. The parameters of the receiving system (front-end) and analyzers (back-end) were described in detail in the related paper (Blaszkiewicz & Kus 2003).

The list of targets includes all methanol masers detected in the Toruń observation programs (Szymczak et al. 2000, 2002) and most of known 6.7 GHz northern hemisphere ($\delta > 0°$.) maser sources described in the literature. Our sole selection criterion of the targets was the 6.7 GHz detection reported.

In the present survey we have searched for 12.2 GHz maser lines towards 161 star-forming sites with previously detected 6.7 GHz masers. We have detected 12.2 MHz line in 49 sources of which 21 are new detections. We also found one extreme absorption source at this frequency. All 12.2 GHz detections have been monitored at 6.7 GHz. Only one source did not show features with the flux above our 3σ level. We also found two additional absorption lines at 6.7 GHz and noted the presence of emitting 12.2 GHz counterparts at the same velocity.

3. DISCUSSION AND CONCLUSIONS

Caswell et al. (1995a,b) showed strong connections between 12.2 GHz and 6.7 GHz spectra in general, but it is noted that the 12.2 GHz masers are slightly weaker. In most of the observed sources only a fraction of features seen at 6.7 GHz have 12.2 GHz counterparts. We designated three groups of 6.7 and 12.2 GHz pairs. In the *first group* (Figure 1, left) the general profile shapes are similar and the velocity ranges of emissions are the same. The best examples are the strongest sources: W3 (OH), 06058+2138, 07299−1651, 18529+0108 or NGC 7538. To the *second group* (Figure 1, right) belong the objects with 12.2 GHz counterpart observed for only a few 6.7 GHz features (usually one). This set of sources is the largest one. The *third designated group* (Figure 2) contains 12.2 GHz emission sources without clear 6.7 GHz counterpart or with 6.7 GHz absorption as a counterpart. The members for this set could be G 28.85+0.50, G 43.17−0.00 at –44.5 km s^{-1} and at 11.5 km s^{-1} where a 12.2 GHz feature is in the gap between two strong 6.7 GHz components. In this

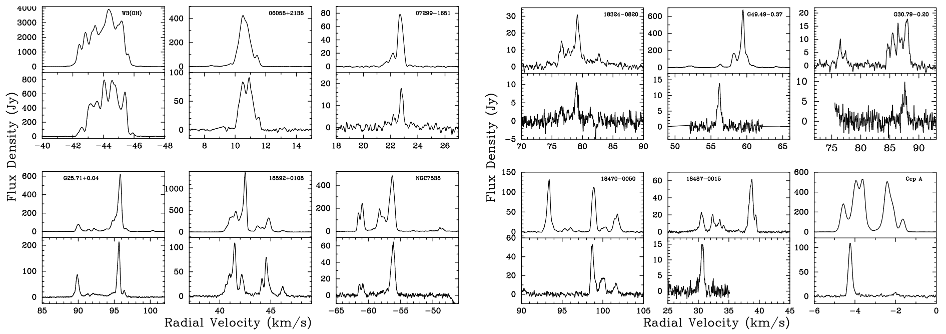

Fig. 1. The comparison of morphology of 6.7 GHz (top) and 12.2 GHz (bottom) spectra. Left part presents pairs of spectra for the first designated group, the right one for the second group.

group we also included two 6.7 GHz absorption sources 19186+1440 and 21381+5000.

For several sources we recorded characteristic double structure (e.g., 18089−1732, 18174−1612 or G25.71−0.04) which could be a hint of rotating disc (e.g., Norris et al. 1993, 1998; Sobolev et al. 1997; Minier et al. 2000). A couple of other profile shapes could also be described in the disc structure terms. As it was shown by Ye Xu (2001), some examples of methanol sources could be explained by a multidisk system. However, this problem is open and other models (e.g., shock fronts) could possibly explain the observed profiles.

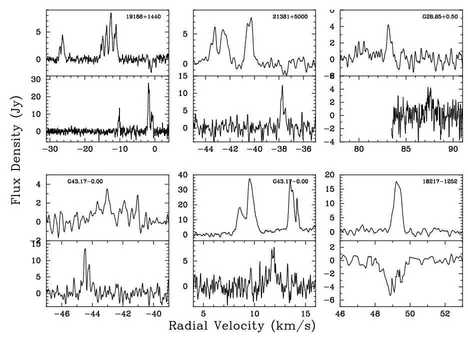

Fig. 2. Same as Fig. 1 but for the third designated group. Panels with sources 19186+1440 and 21381+5000 show 6.7 GHz absorptions with 12.2 GHz emitting counterparts. In the spectra of 18217+1252 we see the reversed situation.

In a few spectra we have observed absorption lines. In our data analysis we put a particular stress on the comparison of 12.2 and 6.7 GHz spectral features. We found three examples of absorption at the observed frequencies which have emitting counterparts at the another frequency (see Figure 2). Previous observations of 12.2 GHz CH_3OH absorption (e.g., Whiteoak et al. 1988; Peng & Whiteoak 1992) were compared with the H_2CO lines, and the authors presented the dependence of emission of both molecules. Theoretical considerations of Cragg et al. (1992) suggested a connection between the methanol masers of different frequencies. They have expressed the opinion that the pump schemes of different methanol transitions are probably linked with each other. Our observations support these theoretical assumptions.

REFERENCES

Batrla W., Atthews H. E., Menten K. et al. 1987, Nature, 326, 49

Blaszkiewicz L., Kus A. J. 2003, A&A (in press)

Caswell J. L., Vaile R. A., Ellingsen S. P. et al. 1995a, MNRAS, 272, 96

Caswell J. L., Vaile R. A., Ellingsen S. P. et al. 1995b, MNRAS, 274, 1126

Cragg D. M., Johns K. P., Godfrey P. D. et al. 1992, MNRAS, 259, 203

Menten K. M. 1991, ApJ, 380, L75

Minier V., Booth R. S., Conway J. E. 2000, A&A, 362, 1093

Norris R. P., Whiteoak J. B., Caswell J. L. 1993, ApJ, 412, 222

Norris R. P., Byleveld S. E., Diamond P. J. et al. 1998, ApJ, 508, 275

Peng R. S., Whiteoak J. B. 1992, MNRAS, 254, 301

Plambeck R. L., Menten K. M. 1990, ApJ, 364, 555

Sobolev A. M., Cragg D. M., Goddfrey P. D. 1997, A&A, 324, 211

Szymczak M., Hrynek G., Kus A. J. 2000, A&AS, 143, 269

Szymczak M., Kus A. J., Hrynek G. et al. 2002, A&A, 392, 277

Whiteoak J. B., Gardner F. F., Caswell J. L. et al. 1988, MNRAS, 235, 655

Ye Xu 2001, Chin. J. Astron. Astrophys., 1, 389