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Imaging of selected sources from the Methanol Multibeam Survey

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Abstract. High angular resolution observations are essential for understanding the nature of maser emission and the sources which excite it. Here we present preliminary results from MERLIN observations of three methanol masers from the Toruń survey. These MERLIN observations are being analysed as part of the interferometric component of the Methanol Multibeam (MMB) Survey which is surveying the Galactic plane at $|b| \leqslant 2^\circ$ for 6.67 GHz methanol maser sources.

Keywords. masers, surveys, stars: formation, ISM: individual (G20.24+0.07, G22.45-0.17, G23.01-0.41) galaxies: individual (Milky Way)

1. Introduction

The process of high mass star formation is poorly understood relative to that for low mass stars. The 6.67 GHz methanol maser is known to be associated exclusively with regions of massive star formation and therefore searching for this maser will aid in the location and further study of these regions. The Galactic Methanol Multibeam Survey (MMB, Green *et al.* 2007) aims to find all (to a noise level of ∼0.2 Jy) of the 6.67 GHz methanol masers in the Galactic plane in the range $|b| \leqslant 2^\circ$. In parallel with single dish observations made using the Parkes telescope and the Lovell telescope at Jodrell Bank, interferometer observations using the ATCA and MERLIN are being used to determine source positions more accurately. An earlier methanol maser survey (Szymczak *et al.* 2002), using the 32 m dish at Toruń in Poland, searched the region $20^\circ \leqslant l \leqslant 40^\circ$, $|b| \leqslant 0^\circ.52$ of the Galactic plane, an area that is being covered by the MMB survey. Of the 100 sources found in the Toruń survey, 60 needed interferometric follow up,of which 44 have now been observed. The preliminary results of the analysis of three sources, G20.24+0.07, G22.45 − 0.17, and G23.01 − 0.41 from both archive and new MERLIN observations, are presented here. The high angular resolution of these observations (∼0.04″) allows the reliable association of the masers with near and mid IR sources. The aim of this project is to determine the properties of these sources and the relationship between different maser species.

2. Sources and results

All three sources show complex velocity structure in their methanol spectra. G22.45-0.17, with the most complex velocity structure, has eight velocity components whose peaks are separated by ∼2 km s^{-1}, and spread over a range of ∼18 km s^{-1}. These features correspond to four spatial components (Figure 1). G23.01 − 0.41, conversely, has a more simple velocity structure and a more complex spatial structure. G20.24+0.07 has been resolved from a single source in the Toruń survey, into two sources separated by ∼8.6″ in the north-east south-west direction, and ∼1 km s^{-1} in velocity.

The sources are at near/far distances of 6/∼12, 5/12.8 and 2.7/15.8 kpc for G20.24 +0.07, G22.45-0.17, and G23.01-0.41 respectively (Caswell & Haynes 1983).

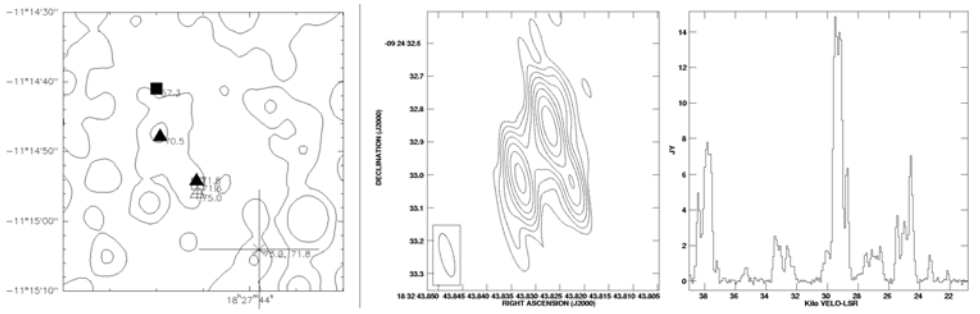

Figure 1. Left: G20.24+0.07 region, RA/Dec in J2000, Grey and contours - 2MASS K-band 2.2 μm. Masers: ▲ MERLIN 6.67 GHz CH_3OH; ■ 22 GHz H_2O; △ 1720 MHz OH; □ 6030/6035 MHz OH; 3 line cross 4660/4750/4765 MHz OH; Diagonal Cross 12 GHz CH_3OH; The size of the '+'s indicate the position accuracy. Velocities, in km s^{-1}, are marked where known. Refs: Caswell *et al.* 1995, Caswell *et al.* 2000, Caswell 2003, Smitts 2003, Szymczak & Gérard 2004, Testi *et al.* 1998. **Middle:** G22.45-0.17 MERLIN 6.67 GHz integrated intensity map with beam shape in the lower left. **Right:** G22.45-0.17 MERLIN spectrum with velocity in km s^{-1}.

Both G22.45-0.17 and G23.01-0.41 are seen in the J=2–1 transition of SiO, which is suggestive of shocked material (Harju *et al.* 1998) as SiO is usually found on grains rather than as a gas. Of the three sources only G20.24+0.07 is coincident with K-band, 2.2μm 2MASS emission, and it is also found to have emission from $C^{32}S$ (J=2–1) which is a tracer of dense gas. The $C^{32}S$ is observed at a velocity of 71.9 km s^{-1} which is comparable to the other maser species in the region with the exception of the 22GHz water maser (Szymczak *et al.* 2005) suggesting that this traces different material, for example an outflow. Only G20.24+0.07 is associated with an IRAS point source (IRAS 18249-1116), which has a luminosity of $2.8 \times 10^4 L_\odot$ (Larionov *et al.* 1999).

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