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

doi:10.1017/S1743921307012938

A MERLIN study of 6 GHz excited OH & 6.7 GHz methanol masers in ON1

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Abstract. MERLIN observations of 6.668-GHz Methanol and 6.035-GHz OH emission from the known massive star-formation region ON1 are presented. Maser components are found to lie at the southern edge of the UCHII with consistent polarization angles across the strongest features. Zeeman splitting of OH shows magnetic field strengths between +0.4 to −5.3 mG and from cross-correlation a tentative methanol magnetic field of −18mG is detected.

Keywords. Star-Formation, Masers, Magnetic Fields, Polarization, ISM: individual (ON1)

1. Introduction

ON1 is an ultra-compact HII region (UCHII) associated with the IRAS source 20081+3122 and is believed to contain a central binary massive proto-star of type B0.3 surrounded by a young stellar cluster. Its near kinematic distance is 1.8 kpc. Recent MERLIN studies of Nammahachak *et al.* (2006) identified 40 groundstate OH maser features with a linear distribution at the southern edge of the UCHII. No previous high resolution 6.668-GHz methanol emission observations exist for ON1, but Szymczak, Hrynek & Kus (2000) observed the associated IRAS source with the 32m Torun dish and found emission with a peak flux of 109 Jy.

MERLIN observations at 6.031, 6.035 and 6.668 GHz were taken in January 2005. Observations were taken in dual polarization with a 0.5 MHz bandwidth over 512 frequency channels, giving velocity widths of $\sim$0.05 km s^{-1}.

2. Results

10 methanol components were observed with velocities between 14.2 km s^{-1} and 15.6 km s^{-1}. 1 OH RHC and 1 LHC component were found at 6.031 GHz with velocities of 13.87 km s^{-1} and 14.19 km s^{-1} respectively. 10 OH LHC and 10 RHC components were found at 6.035 GHz with velocities between 13.52 km s^{-1} and 15.50 km s^{-1}. In concurrence with the groundstate OH, the strongest components lie at the southern edge of the UCHII, perpendicular to the $H^{13}CO^+$ outflow identified by Kumar, Tafalla & Bachiller (2004). The methanol components cover a range of about 0.6″, whilst the OH show a wider spread across about 1.3″, with one component, perpendicularly offset, by about 0.5″. The RHC and LHC Zeeman pair at 6.031 GHz coincides with a 6.035-GHz Zeeman pair to <5.5 mas spatially and <0.049 km s^{-1} in velocity, implying co-propagation. The closest coincidence between methanol and OH is one pair to about 25 mas, with a velocity coincidence of <0.18 km s^{-1}.

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2.1. *Polarization*

The excited OH at 6.035 GHz showed linear polarization varying between 0.9% and 18.5%, whilst the 6.031-GHz frequency had a value of 1.2%. The methanol in comparison varied between 0.2% and 3.6%, with a mean value of 1.2%. The level of methanol polarization is consistent with that found in W3(OH) by Vlemmings, Harvey-Smith & Cohen (2006) and that found in NGC6334F by Ellingsen (2002), where both had the majority of sources displaying less than 5% linear polarization.

The polarization angles of the strongest linearly polarized OH components are consistent across the region, aligned to within 25° of one another. The polarization angle is also consistent with the line of maser distribution (which is itself perpendicular to the known $H^{13}CO^+$ outflow).

2.2. *Magnetic fields*

OH Zeeman pairs were confirmed by close spatial association of opposite circular components, all to within 6 mas. Altogether seven pairs were found, six at 6.035 GHz and one at 6.031 GHz. Splitting factors of 0.0564 $\mathrm{kms^{-1}\,mG^{-1}}$ and 0.0790 $\mathrm{km\,s^{-1}\,mG^{-1}}$ were assumed respectively Fish *et al.* (2006). This gave a magnetic field strength ranging from +0.4 to −5.3 mG for the pairs at 6.035 Ghz and −3.94 mG for the single pair at 6.031 GHz. All the magnetic fields are directed towards us, with the exception of one, and they concur in magnitude with those found previously by Desmurs & Baudry (1998), which varied between −3.6 mG and −6.3 mG. They also compare favourably with the field strengths found for the ground state OH by Nammahachak *et al.* (2006), which varied between −0.4 and −4.6 mG.

For methanol we employed the cross-correlation method of Modjaz *et al.* (2005), modified as per Vlemmings, Harvey-Smith & Cohen (2006). Compared with OH, methanol has a much lower Zeeman splitting factor of 0.0493 $\mathrm{km\,s^{-1}\ G^{-1}}$. Of the two brightest methanol features, the weaker of the two demonstrated a field strength of −18 mG. Without the dynamic range effect this would be a clear detection, however because of it we find the result is at exactly 3σ. As such, the result can be taken as an upper limit, but could represent the first tentative detection of Zeeman splitting in 6.7 GHz methanol.

Acknowledgements

J. A. G. is supported by a PPARC studentship. The authors would like to dedicate this poster paper to the memory of R. J. Cohen.

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