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Parallaxes of 6.7-GHz methanol masers towards the G 305.2 high-mass star formation region

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ABSTRACT

We have made measurements to determine the parallax and proper motion of the three 6.7-GHz methanol masers G 305.200C0.019, G 305.202C0.208 and G 305.208C0.206. The combined parallax is found to be 0.25±0.05 mas, corresponding to a distance of $4.1^{+1.2}_{-0.7}$ kpc. This places the G 305.2 star formation region in the Carina–Sagittarius spiral arm. The inclusion of G 305.2 increases the Galactic azimuth range of the sources in this arm by 40° from Sato et al., allowing us to determine the pitch angle of this spiral with greater confidence to be 19.°0 ± 2.°6. The first very long baseline interferometry spot maps of the 6.7-GHz methanol masers towards these sources show that they have simple linear and ring-like structures, consistent with emission expected from class II methanol masers in general.

Key words: masers – stars: formation – Galaxy: structure.

1 INTRODUCTION

The Northern hemisphere very long baseline interferometry (VLBI) telescopes, including the Very Long Baseline Array, VLBI Exploration of Radio Astrometry and European VLBI Network arrays are currently involved in programmes to determine the parallaxes to high-mass star formation regions (HMSFRs) in the Milky Way, by measuring the relative separation between maser emission associated with these regions and distant background quasars. The sub-milliarcsecond (mas) accurate astrometric measurements between the maser spots and quasars allow the small trigonometric parallax signatures to be detected and the corresponding distances to these Galactic HMSF masers can be determined to an accuracy of 10 per cent at 10 kpc (Reid & Honma 2014).

Using over 100 parallax measurements to HMSFRs in the Milky Way, Reid et al. (2014) have determined the latest Galactic rotation and dynamical parameters, finding the circular rotation speed of the Sun to be $\Theta_0 = 240 \pm 8$ km s^{-1} and distance to the Galactic Centre to be $R_0 = 8.34 \pm 0.16$ kpc. These results have been obtained from measurements primarily from the first and second quadrants of the Galaxy and, in Reid et al. (2016), the authors demonstrate that the complete spiral structure of the Milky Way cannot be clearly distinguished without parallax distances from Southern hemisphere HMSFRs. In 2008, we initiated a project to observe 6.7-GHz class II methanol masers in the Southern hemisphere using the Australian Long Baseline Array (LBA) for parallax determination.

The methanol molecule has a rich radio and millimetre wavelength spectrum (e.g. Müller, Menten & Mader 2004), with more than 30 observed transitions detected in interstellar space. Many of these transitions are observed to exhibit maser emission, which are empirically grouped into two classifications (Menten 1991). Class I methanol transitions are associated with distant parts of the outflows (Voronkov et al. 2006; Cyganowski et al. 2009) or other shocks (Voronkov et al. 2010) and class II masers are associated close to the young star at distances of around $10–10^3$ au (e.g. Ellingsen 2006; Sanna et al. 2010). The 6.7 and 12.2 GHz class II methanol masers are two of the strongest and best-studied transitions of astrophysical maser emission with the 12.2 GHz masers forming a complete subset of the 6.7 GHz emission (Caswell et al. 1995a; Breen et al. 2012). The 6.7 GHz maser is a particularly important transition, as it is exclusively observed towards HMSFRs (Breen et al. 2013). Class II methanol masers are pumped by radiative excitation of the methanol molecule (Sutton et al. 2001) and are known to be strong radio sources with individual features exhibiting point-like structure – even at VLBI resolution – making them excellent candidates for astrometry.

The LBA observations continue to be the only Southern hemisphere astrometric measurements of Galactic HMSFR masers for parallax determination. The first parallax distance to a southern methanol maser source has been presented in Krishnan et al. (2015) and here we provide trigonometrical parallax distances

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