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Imaging of 6.7-GHz Methanol Maser Sources with the Japanese VLBI Network

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We report the recent VLBI imaging of the $5_1 \rightarrow 6_0\, A^+$ transition 6.7 GHz methanol maser sources associated with massive star-forming regions using the Japanese VLBI Network (JVN). Currently, JVN consists of ten antennas spread across Japan from Hokkaido to Ishigaki islands, and operates at frequencies around 6.7, 8.3 and 22 GHz. The observing system of 6.7 GHz now has been installed in six of them; all of four NAOJ VERA stations (Mizusawa, Ogasawara, Iriki, Ishigaki), Yamaguchi 32-m antenna and ISAS Usuda 64-m antenna, with baseline lengths range from 293 to 2270 km. We have carried out the JVN observations toward 6.7 GHz methanol maser sources since 2005, and continue to obtain high angular resolution images of them. In this paper, we present detailed 6.7 GHz methanol maser distributions of three sources, W3(OH), G9.62+0.20 and S269, and describe the results of each individual source.

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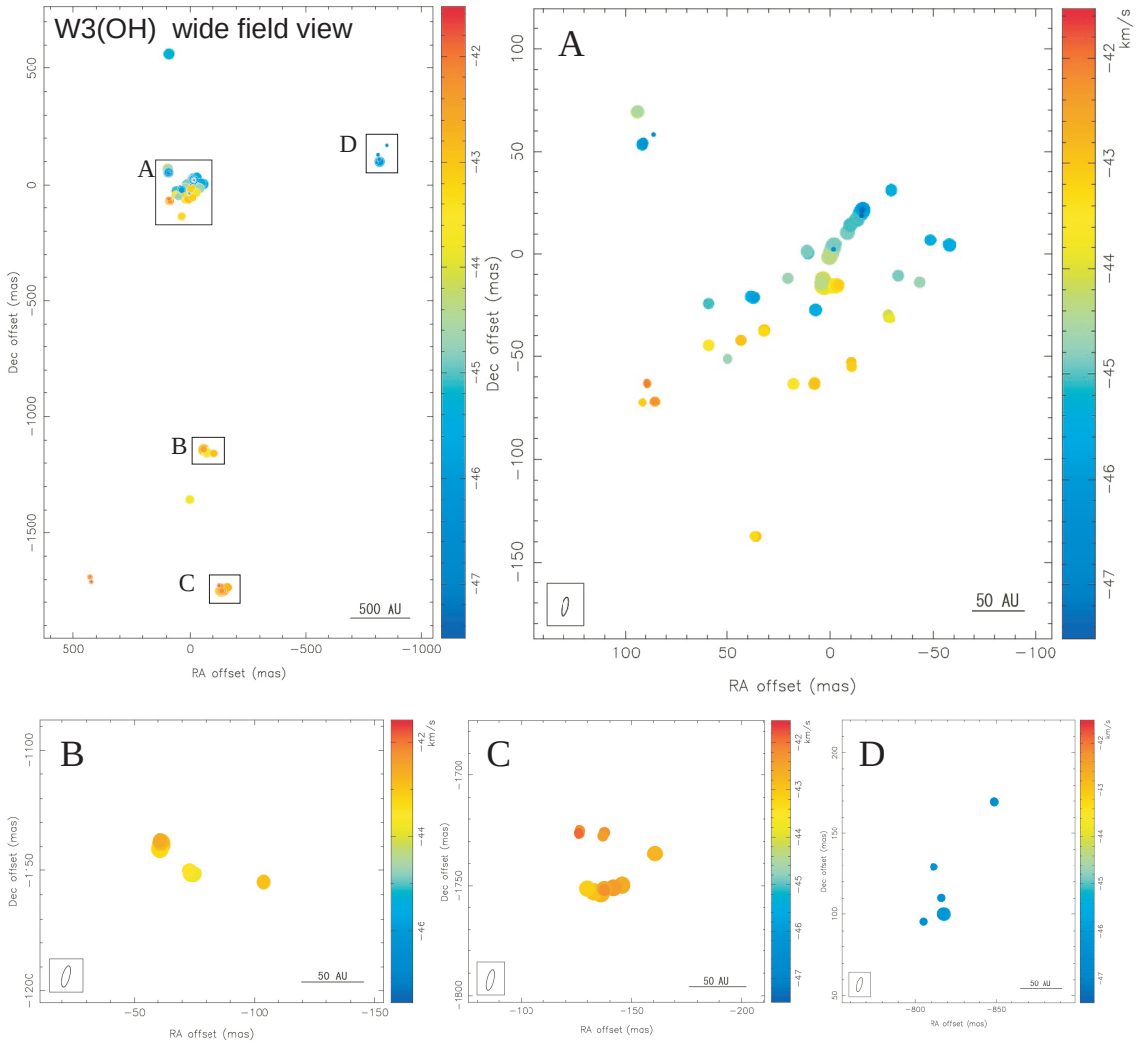

Figure 1: Wide field view of 6.7 GHz methanol maser distribution in W3(OH) (top-left) and close-up image for each clump (A, B, C, D).

1. Results

W3(OH) is one of the most intensively studied star-forming regions at a distance of 2.0 kpc (Hachisuka et al. 2006, Xu et al. 2006) and contains several high- and intermediate-mass young stars and protostars at different evolutionary stages. The 6.7 GHz methanol masers are found in several clumps (Figure 1), and distribution of the maser spots agree well with the previous VLBI images by Menten et al. (1992) and Sugiyama et al. (2008). It implies that the 6.7 GHz methanol maser distribution in W3(OH) has been remarkably stable for ∼15 years from 1992 to 2006. We note that 22 GHz water masers in W3(OH) show a rapid time variability within a few years in contrast with methanol masers (e.g. Xu et al. 2000, Hachisuka et al. 2006).

G9.62+0.20 is a UC HII complex, whose two regions are associated with methanol maser emission. The 6.7 GHz maser in G9.62+0.20 is known as the most powerful methanol maser, and it is organized into two groups in the VLBI map (Figure 2a). The main group consists of two sub

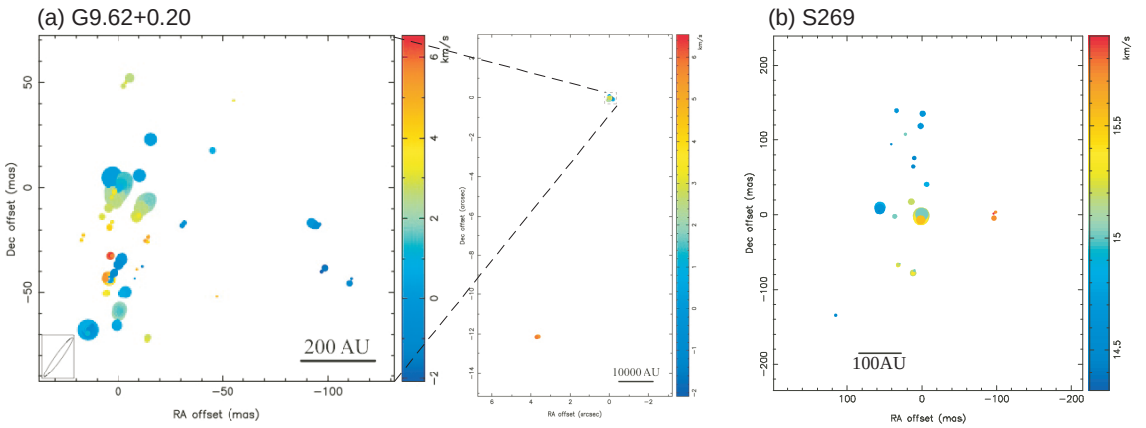

Figure 2: (a) Wide field view and close-up image of 6.7 GHz methanol maser distribution in G9.62+0.20. (b) The distribution of 6.7 GHz methanol masers in S269.

groups, and the maser distribution is similar to the 12 GHz VLBI maps by Minier et al. (2000) and Goedhart et al. (2005).

S269 is an HII region located in the outer Galaxy at a distance of 5.28 kpc (Honma et al. 2007). The 6.7 GHz methanol masers in S269 are probably associated with the young IRAS source. The spectrum of 6.7 GHz methanol maser consists of a single feature at V_{LSR} of 15.2 km s^{-1}, and it is shifted from the peak of 22 GHz water maser spectrum (19.6 km s^{-1}). The main bright methanol masers distributed along the east-west direction (Figure 2b). We note that the 22 GHz water masers in S269 also show an aligned distribution along the east-west direction on a scale of 0.4 mas (Honma et al. 2007).

Acknowledgments

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