Cosmic Masers: Proper Motion toward the Next-Generation Large Projects
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A Multiwavelengh study towards Galactic HII region G10.32-0.26

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Abstract. We present the results of high-resolution continuum and molecular line observations towards the Galactic HII region, G10.32-0.26. The continuum map with ALMA reveals the five cores with masses ranging from 2.5–9.2 $M_\odot$. The results show that the brightest peak, Peak 1, is an HCHII region with an excitation temperature of ∼12000 K, an electron density of 3.4×10^7 cm^3, and a radius of 14 au. The central object is estimated to be a B0.5 star. The class II 6.7 GHz CH_3OH maser coincides with Peak 1, implying class II CH_3OH maser is associated with a later evolutionary stage of star formation. Using KaVA and KVN observation, we detect the class I 44 and 95 GHz CH_3OH masers near the weakest peak, Peak 5. We successfully imaged class I 95 GHz CH_3OH masers with VLBI for the first time. In Peak 5, the high-velocity SiO emission also exists. The continuum emission can be modelled with grey-body dust emission with T_d ∼30 K, and the molecular species are poor near Peak 5, suggesting Peak 5 is in an early stage of star formation.

Keywords. Star formation, HII region, Masers

1. Introduction

Class I and II CH_3OH masers are one of the common maser species in star-forming regions. High-resolution observations of Class II CH_3OH masers show that they are associated with disk/outflow around massive YSO (De Buizer 2003; Bartkiewicz *et al.* 2009). In contrast, the detailed kinematics and physical condition of the class I CH_3OH masers are poorly understood due to a lack of high-resolution observations. We conducted VLBI and ALMA observations towards G10.32−0.26 to reveal the physical conditions of the star-forming region where the bright class I and II CH_3OH masers arise.

The 44 GHz class I CH_3OH masers were observed using KaVA (KVN and VERA array). Additionally, the 95 GHz class I CH_3OH masers were observed simultaneously using the multi-frequency receiving system of KVN antennas. The 6.7 GHz CH_3OH maser observation was conducted with JVN (Japanese VLBI Network), including VERA 4 stations, Hitachi, Yamaguchi, and Kashima.

For high angular resolution continuum and molecular line observations, we conducted ALMA observations in band 3 and band 6. We also conducted EVLA observation at 44 GHz for continuum and class I CH_3OH maser polarization.

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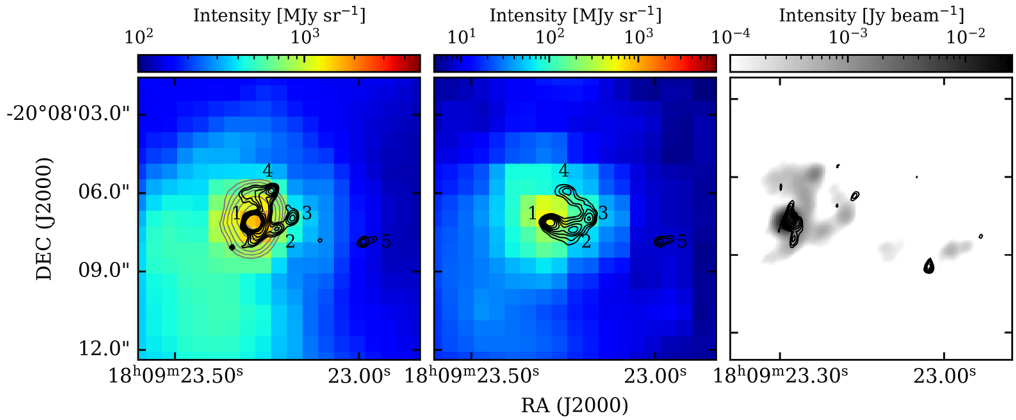

Figure 1. Left: 102 GHz ALMA continuum image (black contour) overlayed with the 5 GHz continuum emission from the CORNISH survey (grey contour) and the *Spitzer* 8 μm emission (color). Center: 223 GHz ALMA continuum image (black contour) overlaid on the *Spitzer* 4.5 μm emission (color). Right: 46 GHz continuum emission (black contour) overlaid on the ALMA band 3 continuum emission (grey).

2. Results

With ALMA band 3 and 6 observations, we identified five continuum peaks over $10'' \times 10''$ area (Figure 1). On the other hand, only Peak 1 is detected with 44 GHz EVLA observation. The masses of cores are estimated to be 2.5–9.2 $M_\odot$, assuming optically thin dust emission.

The compact thermal CH_3OH emission is detected at Peak 1 and 4 in the velocity range of $V_{\rm lsr} \sim$32–38 km s^{-1}, while Peak 2 and 3 show weak thermal CH_3OH emission with $V_{\rm lsr} \sim$ 32 km s^{-1}. The compact H30α emission was found in the vicinity of Peak 1. Sulfur-bearing molecules and DCN with $V_{\rm lsr} \sim$32–34 km s^{-1} are detected in the area between Peak 1 and Peak 2, and in the vicinity of Peak 4. The 6.7 GHz CH_3OH maser was detected at Peak 1 in the $V_{\rm lsr} \sim$36–39 km s^{-1} velocity range and shows the velocity gradient in the east-west direction. Assuming Keplerian rotation, we estimate the central mass to be $\sim$14 $M_\odot$.

In Peak 5, SiO v=0 emission ($V_{\rm lsr} \sim$20–60 km s^{-1}) and thermal CH_3OH emission ($V_{\rm lsr} \sim$32–36 km s^{-1}) were detected. Using a fringe-rate map, we confirmed that class I 44 and 95 GHz CH_3OH masers are located at Peak 5. The positions and velocity distributions of masers are consistent with thermal CH_3OH emission.

To characterize the physical properties of dust cores, we compared the observed continuum flux with the modelled SED and determined the physical parameters by trial and error. Based on the observational results, we adopted free-free emission with a truncated power-law density distribution for the modelled SED of Peak 1 (Olnon 1975). A model of the HCHII region with an excitation temperature of 12000 K, a radius of 14 au, and electron density $n_0 \sim 3.4 \times 10^7$ cm^{-3} matches the observed continuum emissions. The excitation parameter $U \sim 7.1$ pc cm^{-2} implies that the central object is a B0.5 ZAMS star with a total luminosity $L \sim 10^4$ $L_\odot$ (Panagia 1973).

For Peak 2–5, we adopted an optically thin, modified grey body for SED fitting (Rathborne *et al.* 2010). The results show they are embedded in cold dust ($T_{\rm d} \sim$30–50 K). In Peak 5, we detected 44 and 95 GHz class I CH_3OH masers and elongated SiO emission, which is a tracer of shocks and collimated jets in star-forming regions. In contrast, a deficiency of molecular lines and a low dust temperature of $\sim$30 K suggests that Peak 5 is in the very early phase of star formation.

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References

Bartkiewicz, A., Szymczak, M., van Langevelde, H. J., *et al.* 2009, *A&A*, 502, 155
De Buizer, J. M. 2003, *MNRAS*, 341, 277
Olnon, F. M. 1975, *A&A*, 39, 217
Panagia, N. 1973, *AJ*, 78, 9
Rathborne, J. M., Jackson1, J. M., Chambers, E. T., *et al.* 2010, *ApJ*, 715, 310

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