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ALMA observations of the environments of G333.0162+00.7615

Toktarkhan Komesh[1,2], Aruzhan Omar[2], Guido Garay[3], Zhandos Assembay[2], Nazgul Alimgazinova[2], Nurman Zhumabay[4] and Meiramgul Kyzgarina[2]

[1]Energetic Cosmos Laboratory, Nazarbayev University, Astana 010000, Kazakhstan
email: toktarkhan.komesh@nu.edu.kz

[2]Al-Farabi Kazakh National University, Almaty 050040, Kazakhstan

[3]Departamento de Astronomía, Universidad de Chile, Las Condes, Santiago 7550000, Chile

[4]Abay Kazakh National Pedagogical University, Almaty 050010, Kazakhstan

Abstract. We have carried out ALMA observations toward the environments of G333.0162+00.7615 which was considered as a candidate of high-mass young stellar object (HMYSO) in previous studies. Our dust continuum, molecular line emission and radio recombination line emission observations show that this source is not HMYSO associated with hypercompact (HC) HII regions. Instead, we discovered two new hot cores associate with earliest stages of high mass star formation region. We estimated the rotational temperatures of these cores about 270 K from J=14→13 rotational transition of CH_3CN ladder. The moment maps show velocity gradients confirming that this cores are rotating.

Keywords. ISM: molecules — ISM: clouds — ISM: cores — stars: formation — stars: massive — ISM: kinematics and dynamics

1. Is G333.0162+00.7615 a high-mass young stellar object?

The RMS (Mottram et al. 2011) source G333.0162+00.7615 was catalogued as high-mass young stellar object (HMYSO) candidate by Urquhart et al. (2007). Due to its rising spectral index between 5.0 and 8.4 GHz, Guzmán et al. (2012) considered this source as a jet candidate.

To determine whether hot molecular cores are common around HMYSOs we observed this source using ALMA in Band 6 (256.3-259.6 GHz), dust continuum and molecular line emission arising from two molecules, SO_2 and CH_3CN (256.3-259.6 GHz). We did not detected emission in the molecular lines nor in the H29α radio recombination line (RRL), indicating that this HMYSO candidate is not associated with a a hot core nor a compact HII region. Instead, in the environments we discovered two hot cores,likely to be associated with earliest stages of high mass star formation. They are labeled as cores A and B in Figure 2 and their peak positions are at (RA, Dec) (J2000) = ($16^h15^m18.44^s$, -49°48′44.04″) and (RA, Dec) (J2000) = ($16^h15^m17.67^s$;-49°48′49.13″), respectively. These cores, located at the distance of $\sim$ 9 pc from G333.0162+00.7615, are associated with the ATLASGAL source AGAL333.018+00.766 (Contreras et al. 2013). In the following sections, we show the moment maps and rotational temperature analysis of these two cores.

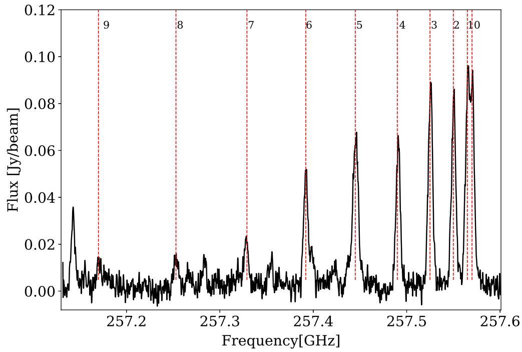

Figure 1. Methyl cyanide spectra obtained toward core A, (RA, Dec) (J2000) = ($16^h15^m18.44^s$, $-49°48'44.04''$). K components of the CH_3CN 14-13 transition are marked with dashed lines ($V_{LSRK} = -47.90$ kms^{-1}).

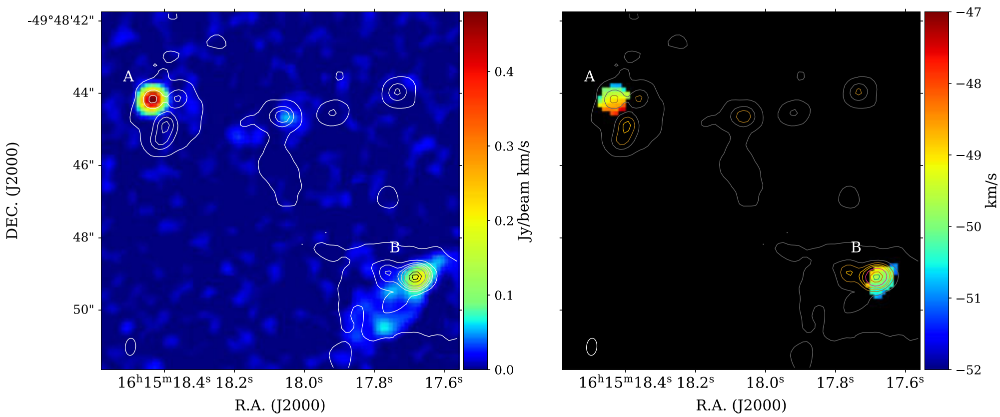

Figure 2. Image of the velocity integrated line emissions (left panel) and moment one image (right panel) of the K=3 of 14-13 ladder of CH_3CN toward the environments of G333.0162+00.7615. Superimposed are contours of the continuum emission. Contour levels are 0.001, 0.006, 0.011, 0.021, 0.031,0.05 and 0.06 Jy/beam. The white ellipse shown at the bottom left corner indicates the beam size.

2. Molecular gas

Figure 1 presents the spectrum of the $J = 14 \rightarrow 13$ rotational transition of CH_3CN integrated over a region of in 0.23″ in size, centered on core A. Nine K components of this rotational transition were observed in this source.

Figure 2 shows the velocity integrated line emissions map (left panel) and moment 1 map (right panel) of the K=3 of 14-13 ladder of CH_3CN. Superimposed are contours of the continuum emission. Contour levels are 0.001, 0.006, 0.011, 0.021, 0.031,0.05 and 0.06 Jy/beam. Clearly seen in these maps are two compact molecular cores (left panel, A and B). The continuum emission shows several features, two of them associated with cores A and B. Interestingly, the continuum emission near core A shows three compact sources with the brightest one, located in the south, not being associated with molecular emission. The moment 1 map (right panel) clearly shows velocity gradients within the cores, from north-east (NE) to south-west (SW) with an average velocity of ~ -48 km s^{-1} in core A, and velocity gradients from SW to NE with an average velocity of ~ -50 km s^{-1} in core B. SO_2 30-30 moment maps of SO_2 (30-30) shows the same features as CH_3CN confirming that these cores are rotating.

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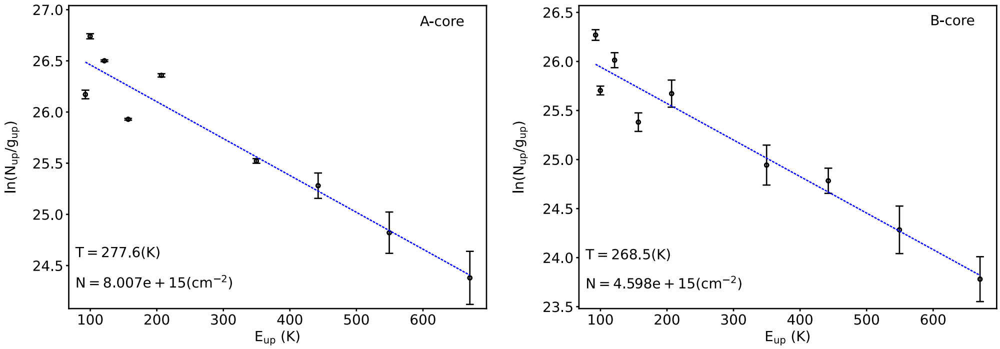

Figure 3. Rotational diagrams at the peak positions of the cores A (left panel) and B (right panel).

3. Rotation diagram analysis: estimation of gas temperature

We estimated the CH_3CN rotation temperature (T_{rot}) and column density using the population-diagram method (see Araya et al., 2005) assuming LTE and low optical depths. The column density in the (J, K) state, N_{JK}, is given by

$$\left(\frac{N_{JK}}{cm^2}\right) = 1.67 \times 10^{14} \frac{g_{JK}}{S(I,K)} \frac{J}{(J^2-K^2)} \left(\frac{\nu_0}{GHz}\right)^{-1} \times \left(\frac{\mu}{debye}\right)^{-2} \left(\frac{\int T_B dv}{Kkms^{-1}}\right) \tag{1}$$

where g_{JK} is the statistical weight for the state in question, S(I, K) is the spin weight degeneracy factor given by equation (A4) (Boucher et al. 1980), ν_0 is the frequency of the (J, K) → (J–1, K) transition, $\mu = 3.91$ debye, and T_B is the brightness temperature.

Figure 3 displays the rotational diagrams at the peak positions of the cores. The rotational temperatures of A and B cores are 277.6 K and 268.5 K, and the column densities are 8.01×10^{15} cm^{-2} and 4.6×10^{15} cm^{-2}, respectively.

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Supplementary material

To view supplementary material for this article, please visit https://doi.org/10.1017/S1743921323000121.

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