

A Study on the Methyl Formate in Its Ground and Torsional Excited States Toward Orion KL Using ALMA Science Verification Data

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Methyl formate (HCOOCH_3) was first identified toward Sgr B2 [1] and more than 1000 transitions were identified in the star-forming regions including Orion Kleinmann-Low (KL) since then. Methyl formate has an internal rotor which is equivalent to the torsional vibration. This mode is a low-lying state. The rotational transition in the first torsional excited state of this molecule was first identified toward Orion KL in 2007 [2]. In 2012, even transitions in the second torsional excited state were observed by using the Nobeyama 45 m Radio Telescope [3].

In this study, we analyzed the ALMA science verification data of Orion KL (band 6) that contains many transitions in the ground and torsional excited states. It was confirmed in the previous study [3] that there is a difference between the vibrational temperature and the rotational temperature. The higher spatial resolution of this new ALMA data will help us to clarify the difference. Figure 1 shows the integrated intensity maps of methyl formate. These maps show the similarity of population in each vibrational state. We have analyzed two velocity components toward the Compact Ridge and one velocity component toward the Hot Core. It was confirmed that the vibrational temperature and the rotational temperature of each component agreed within their uncertainties [4].

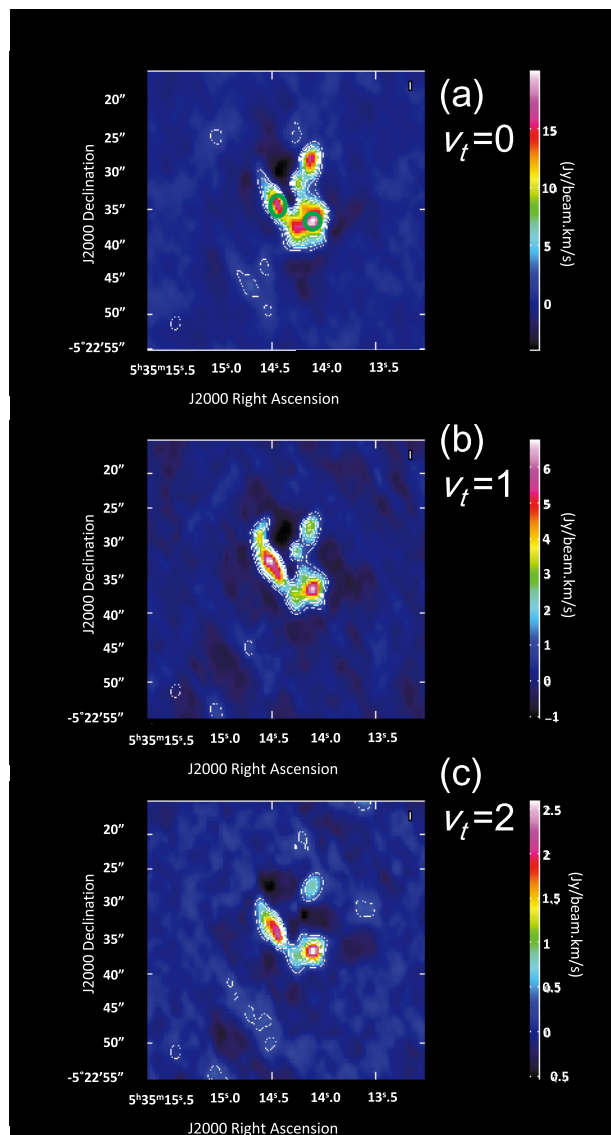


Figure 1: Integrated intensity maps of methyl formate in the ground, the first torsional excited, the second torsional excited states. The green circles shown represent the Compact Ridge and Hot Core.

References

- [1] Brown, R. D., et al.: 1975, *ApJ*, **197**, L29.
- [2] Kobayashi, K., et al.: 2007, *ApJ*, **657**, L17.
- [3] Takano, S., et al.: 2012, *PASJ*, **64**, 89.
- [4] Sakai, Y., Kobayashi, K., Hirota, T.: 2015, *ApJ*, **803**, 97.