Q43a

Abundance and Excitation Mechanism of Methyl Formate ($HCOOCH_3$) in the Second Torsionally Excited State ($v_t = 2$) in Orion KL

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We report the abundance and excitation mechanism of methyl formate ($HCOOCH_3$) in the second torsionally excited state ($v_t = 2$) of the methyl internal rotation in Orion KL. Recent progress on microwave spectroscopy of methyl formate in laboratory and sensitive radioastronomical observations made it possible to detect methyl formate in this state (Y. Sakai et al. at the ASJ meeting 2011 spring, Q04a).

The column density obtained is $(3.0 \pm 1.5) \times 10^{14}$ cm^{-2} in this state. In addition, we also observed lines in the ground and first torsionally excited states ($v_t = 0$ and 1) in Orion KL with the Nobeyama 45m radiotelescope. The obtained rotational temperatures are 43 ± 9 K and 53 ± 8 K for the $v_t = 0$ and 1 states, respectively. The column densities are $(3.8 \pm 1.2) \times 10^{15}$ cm^{-2} and $(9.8 \pm 2.3) \times 10^{14}$ cm^{-2} for the $v_t = 0$ and 1 states, respectively, which are factors of 13 and 3 larger than that in the $v_t = 2$ state. The data of these three states can be explained by a single vibrational temperature of 124 ± 5 K, which is significantly higher than the rotational temperatures. As excitation mechanisms, there are two possibilities, collision with H_2 and pumping by FIR radiation. Considering the temperature difference and Einstein's A coefficients of the torsional states, we cannot eliminate one of these mechanisms. The present results further indicate that many more unidentified lines in Orion KL will be due to low-lying excited states of methyl formate and other organic molecules.