

Mapping observations of deuterated species toward the low-mass protostar L1527 with ALMA

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We observed formaldehyde (H_2CO) and its deuterated species (HDCO and D_2CO) toward the Class 0 low-mass protostar L1527 with ALMA. The distributions of H_2CO and the deuterated isotopologues are found to be clearly different from each other. The emission of H_2CO is strong around the protostar ($r < 250$ au), as previously reported [1]. On the other hand, the deuterated species mainly reside in the outer envelope ($r \sim 1000$ au). It has been thought that H_2CO is efficiently produced on dust grains and released into the gas phase in the warm region near the protostar. This process is indeed the case for H_2CO , because its distribution is concentrated in the vicinity of the protostar, where the temperature is higher than the desorption temperature of ~ 40 K [2]. On the other hand, the deuterated species are likely produced in the gas phase and/or released from dust grains via non-thermal processes, because the kinetic temperature derived from the different K transitions of D_2CO is as low as 20 K.

The D/H ratio in the outer envelope is derived to be high ($\text{HDCO}/\text{H}_2\text{CO} \sim 0.8$). The high D/H ratio in the outer envelope is confirmed also for the CCD/CCH case, based on our recent ALMA observations. On the other hand, the D/H ratios are found to be low in the vicinity of the protostar (\sim a few percent). Hence, the decrease in the deuterium fractionation is confirmed along the protostellar envelope within a 1000 au scale.

Figure 1: The integrated intensity maps of the H_2CO ($5_{15-4_{14}}$), D_2CO ($4_{04-3_{03}}$ and $4_{23-3_{22}}$), and HDCO ($4_{13-3_{12}}$) lines obtained with the ALMA ACA array.

References

- [1] N. Sakai et al., 2014, ApJL, 791, 38
- [2] J. J. Tobin et al., 2013, ApJ 771, 48