Deuteration in the initial condition of the high-mass star formation

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Knowledge of the initial chemical conditions of high-mass star-forming regions (HMSFRs) is important for understanding how such stars form. Deuteration is a key process since it allows us to probe the earliest stages of star formation.

Using IRAM-30 m telescope, we carried an imaging line survey at 1.3 mm–4.3 mm towards the darkest, coldest southern end of the filament G28.34+0.06 [1, 2]. This region covers a pair of high- mass clumps P1 and S, which are 2 pc-apart on the projection plane of the sky, and their kinematical features indicate different evolutionary stages. (1) Analysing the profiles of key physical and chemical parameters, we studied the deuteration of six species (NH_2D, N_2H^+, HCN, HNC, HCO^+, and CH_3OH), and unveiled the chemical gradient from the more evolved protostellar clump P1 to the extremely young protostellar clump S. (2) At a spatial resolution of 0.8 pc, we found the deuterations of N_2H^+, HCO^+, and HNC are more efficient in the cold environment. In particular, HCO^+ and HNC shows higher deuteration than previous studies towards the dark clouds by a factor of 1–2 magnitude. In contrast, deuteration of NH_3 and CH_3OH show clear enhancement towards the location between P1 and S, where CO has the largest depletion (~250). (3) Supported by our gas-grain model [3], the variations in deuteration of different species result in their different gas-grain forming paths.

This comparable chemical study towards a pair of young HMSFRs in the same natal cloud excludes the impacts from the environmental difference, illustrates the potential of taking the deuteration efficiency of species with different gas-grain forming paths as a tool in diagnosing the evolutionary stage of a HMSFR. The result of this pilot study will be ground by observations on a larger sample of source pairs in the similar dark clouds [4].

References

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