Chemical Differentiation and Fractionation in Prestellar Cores

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In molecular clouds there are high density ($\geq 10^5$ cm^{-3}) cores with low temperatures (~8−10 K), which are called prestellar cores. They are considered to be on the verge of star formation, and some of them indeed show the evidence of gravitational contraction. In recent years, chemical differentiation is found in these cores. CO and CS are heavily depleted in the central regions, while N_2H^+ has almost constant abundance. On the other hand, NH_3 abundance is slightly enhanced towards the center. We performed a hydrodynamic simulation of gravitational contraction, and then solved a chemical reaction network of the gas-phase and grain-surface reactions in multiple fluid parcels to obtain molecular distributions within cores. Our model reproduces both the observed contraction velocities and the chemical differentiation. Since molecular distributions are determined by the balance between dynamical time scale and chemical time scale, variation of depletion degree observed among cores can be explained by the difference in the contraction time scale, which is determined by the ratio of the gravitational force to the pressure force within the core. Deuterium fractionation is also included in our chemical network. Very high D/H ratios, such as H_2D^+/H_3^+, D atom/H atom and ND_3/NH_3, are predicted, which are also consistent with the recent observations.