PHYSICOCHEMICAL PROCESSES ON ICE DUST TOWARDS DEUTERIUM ENRICHMENT

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Water and some organic molecules were found to be deuterium enriched toward various astronomical targets. Understanding the deuterium-fractionation process pertains directly to know how and when molecules are created. Although gas phase chemistry is certainly important for deuterium enrichment, the role of physicochemical processes on the dust surfaces should be also considered. In fact, the extreme deuterium enrichment of formaldehyde and methanol requires the dust grain-surface process. In this context, we have performed a series of experiments on the formation of deuterated species of water and simple organic molecules. From the results of these experiments and related works, I will discuss the key processes for the deuterium enrichment on dust. For deuterium chemistry, another important issue is the ortho-to-para ratio (OPR) of H_2, which is closely related to the formation of H_2D^+ and thus the deuterium fractionation of molecules in the gas phase. Because the radiative nuclear spin conversion of H_2 is forbidden, the ortho-para conversion is very slow in the gas phase. In contrast, it was not obvious how the nuclear spins behave on cosmic dust. Therefore, it is desirable to understand how the OPR of H_2 is determined on the dust surfaces. We have tackled this issue experimentally. Using experimental techniques of molecular beam, photostimulated-desorption, and resonance-enhanced multiphoton ionization, we measured the OPRs of H_2 photodesorbed from amorphous solid water at around 10 K, which is an ice dust analogue. It was first demonstrated that the rate of spin conversion from ortho to para drastically increases from 2.4×10^{-4} to 1.7×10^{-3} s^{-1} within the very narrow temperature window of 9.2 to16 K. The observed strong temperature cannot be explained by solely state-mixing models ever proposed but by the energy dissipation model via two phonon process. I will present our recent experiments regarding this.