On the formation of comets based on the ortho-to-para ratio of molecules

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Comets are thought to be remnants of planetecimals in the protosolar nebula. In order to study the formation of our solar system, it is important to investigate the origin of comets from various viewpoints. The ortho-to-para ratio of the molecules which have protons at the symmetrical positions such as H2O, is one of primordial characters in comets. The conversion between ortho and para species is strictly forbidden in gas phase, and probably very slow even in solid phase.

The ortho-to-para ratio (OPR) of cometary molecules is investigated well for water. There are no reliable reports on other molecules. The OPR of cometary water indicates about 30 K for three comets. This is consistent with formation temperatures estimated from DCN/HCN or DHO/H2O, and so on.

Recently we developped the new way to determine the OPR of ammonia in comets using NH2 (which is a photodissociation product of ammonia). The emission lines of NH2 are recognized in the optical spectrum of a comet, and it is easy to get high-S/N spectrum for it. Altough the observation for OPR of water is prevented by the telluric atmosphere, NH2 can be observed easier without such influence. We can derive simple relation between OPR of ammonia and OPR of NH2 produced from ammonia through the photodissociation reaction. We observed two long period comets (C/1999S4, C/2001A2) by the Subaru telescope and High Dispersion Spectrograph (HDS). The derived equilibrium temperatures (or spin temperatures) are 28K and 26K, respectively. These values are consistent with the spin temperature of water in comets. This fact may indicate the scenario that both water and ammonia formed and condensed on cold dust grains in solar nebula or presolar molecular cloud.

In the future, we can derive more and more ammonia spin temperatures for many comets because of the simplicity of our method.