Spectroscopic Investigation of Large Hydrogen Clusters at Low Temperatures

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Quantum clusters of molecular hydrogen have been attracted great attention because of its possible superfluid phase. Parahydrogen has been predicted to undergo Bose-Einstein condensate (BEC) and to exhibit a superfluid phase below 4 K [1], but it has not been observed yet due to the freezing of bulk hydrogen systems at 13.8K. Clusters are known to have significantly lower freezing temperature than their bulk systems due to the size effect,[2] so that one may be able to achieve fluid phase of molecular hydrogen below the predicted superfluid transition temperature. Thus, clusters of molecular hydrogen are very appealing system for the observation of possible superfluid phase of hydrogen. Here, we report our recent investigation of large (N=100 - 100,000) hydrogen clusters at very low temperatures created by the expansion of cold, compressed hydrogen gas into vacuum. Laser induced fluorescence (LIF) and infrared absorption of several molecules doped in hydrogen clusters showed clear evidence of non-rigidity of hydrogen clusters at 0.4 K or 4 K. Furthermore, the observed spectra showed clear dependence on the cluster size as well as ortho-para concentration of hydrogen molecules. We will discuss the properties of large hydrogen clusters and possible superfluid phase of molecular hydrogen based on our observed spectra.

[1] V. L. Ginzburg and A. A. Sobayanin, JETP Lett. **15**, 242 (1972).
[2] R. S. Berry, Adv. Chem. Phys. **70**, 74 (1988).