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Spectroscopy of large hydrogen clusters in He droplets and H_2 droplets.

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Clusters of molecular hydrogen (H_2) at low temperatures have been attracted much attention because of the possible superfluid phase of molecular hydrogen. Parahydrogen has been predicted to undergo Bose-Einstein condensate (BEC) and to exhibit a superfluid phase below 6 K. However, since the freezing point of H_2 (14 K) is much higher than the predicted superfluid transltion temperature, the supercooling of bulk H_2 system has not been achieved despite many attempts. Clusters are known to exhibit lower freezing and melting temperatures than their bulk system due to the size effect. In addition, the melting temperature may become significantly lower than the freezing temperature in such clusters, and coexistence of liquid and solid phases between the melting and freezing temperatures has been predicted theoretically. Thus, clusters of molecular hydrogen are very appealing system for the observation of possible superfluid phase of molecular hydrogen. Since superfluid is a macroscopic property, we have studied properties of hydrogen clusters with fairly large size ($N = 100 - 10^6$) by using He droplet spectroscopy. Some advantages of using droplet spectroscopy for this study include (1) cluster size can be precisely controlled by its pickup process, and (2) the temperature of clusters is well defined. Laser induced fluorescence of several molecules doped in H_2 clusters showed clear evidence of non-rigidity of hydrogen clusters at 0.4 K or 4 K. We have also observed a clear difference in the LIF spectra between *parahydrogen* and *orthohydrogen* clusters. We will discuss the properties of large parahydrogen clusters from the dependence on the cluster size and concentration of orthohydrogen.