II-B Spectroscopic Studies on Atoms and Ions in Liquid Helium

Atoms and ions in liquid helium are known to reside in bubble-like cavities due to the Pauli repulsive force between electrons. Physical properties of these exotic surroundings are determined by the potential energy of the impurity-He_n system, the surface tension energy of the liquid helium, and the pressure-volume work. Spectroscopic studies of such impurity atoms and ions in liquid helium are expected not only to give interesting information on the structure and dynamics of the bubbles but also to contribute to the study on physical properties of superfluid liquid helium.

II-B-1 Laser Spectroscopic Studies of Mg Atoms in Pressurized Liquid Helium

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We have measured excitation and emission spectra of the $3s^2\ {}^1S_0$–$3s3p\ {}^1P_1$ transition of Mg atom in pressurized liquid helium-4 and helium-3. We have found that all these spectra show large spectral widths and large peak shifts with respect to the transition wavelength of free Mg atoms; while the excitation spectra are shifted toward the blue side, the emission spectra toward the red side. Although these are well-known spectral properties for impurity atoms in liquid He, we have also found that the peak wavelengths of the emission spectra, in particular, remain constant or slightly increase with the increasing liquid pressure. The latter is an interesting spectral property peculiar to this transition of Mg, because, for other atoms, such as Ba, Rb, Cs, Tm and Ca, and for other transitions of Mg, the increase of the liquid pressure always shifts their emission spectra toward shorter wavelength. Our bubble model calculation has successfully reproduced these properties of the Mg spectra, and has given a reasonable explanation to those peculiar properties. Moreover, further considerations based on the calculated results have suggested the possibility of the formation of a $Mg(3s3p\ {}^1P_1)He_n$ exciplex in a bubble.