§19. Spectroscopy Measurement on an Afterglow Plasma Created by Pulsed Discharges in Liquid Helium

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At a temperature, T, below 2.16 K, liquid helium (LHeII) includes a superfluid component which has no viscosity and zero entropy. Superfluid is a Bose-Einstein condensate which can be regarded as a "mechanical vacuum." We proposed a possibility to create thick cryogenic plasmas in LHeII instead of vacuum environment.[1]

The helium positive and negative ions in LHe are considered to be semi-classical objects,i. e. an impurity. Schwarz measured the zero field mobilities of both ions in LHe over 0.37 K<T<5.18 K.[2] At T=0.37 K, they increase by amounts, respectively, 3x10E4 and 10E6 times the lowest values at 4.16 K. Such increased mobilities may enable the ions to diffuse easily and to distribute flatly in the ambient LHeII. To begin with our attempt, a preliminary spectroscopic measurement of the afterglow plasma produced in LHe by pulsed discharges has been carried out.

Near the bottom of a glass Dewar bottle filled with LHe, a pair of tungsten rod with 1 mm diameter are installed. their separation is 1.5 mm. Pulse voltages of -25 kV, peak currents 50 A and duration 0.6 μs are repeatedly applied to the electrodes. Light emission from afterglow of the pulsed discharges is observed by a multi-channel spectrometer through a vertical slit of the Dewar bottle.

In Fig. 1, an example of line profiles at 587.6 nm is shown for various times after the end of pulsed discharges, Initially, a dominant broad continuum light is observed, and it diminishes rapidly in time. Also, the widths of line spectra are considerably large, and they decrease in time. Following Griem's textbook, the data analysis has been made. From line to continuum ratios, the temperature evolution is evaluated from 33,000 k to 19,000 K in a period of 2 μs. Assuming Stark broadening to line widths, the density

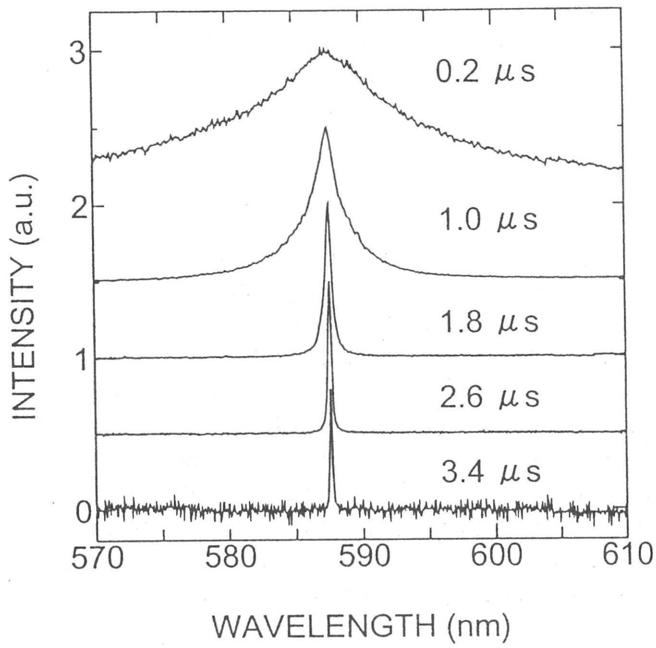

Fig. 1 Changes in the shape of 587.6 nm line in time after the pulsed discharges in liquid helium at 4.2 K and 1 atm. .

is estimated to change from 2x10E18 to 8x10E16 cmE-3 during 4 μs. During discharges, a bubble might have been formed between the electrodes, and it is supposed to shrink in afterglow period. At that time, the light intensity becomes weak, and tenuous plasmas are estimated to be created in LHe. Further detailed measurements are under way.

References
1) Minami,K., et al.,Jpn. J. Appl. Phys.Vol.34,Part 1(1995)271.
2) Schwarz,K.W., Phys. Rev. 11 A 6(1972)1017.