## § 18. Magnetic Confinement of Cryogenic Plasma in Super-fluid Liquid Helium

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The effect of magnetic confinement has been investigated on the density decay of afterglow plasma produced by pulsed discharges between needle electrodes immersed in liquid helium (LHe) in superconducting coils. The coils are a pair of split type solenoid coils made of copper stabilized NbTi alloy wires of diameter 0.42 mm. The sizes of a coil are outer and inner diameters of 68 mm and 20 mm, the total length of 150 mm. Turn number is 4158×2 and inductance is 477×2 mH. Two coils produce a cusp or mirror-type field with maximum value 2.0 T, when DC current 25 A is fed. A pair of needle tungsten electrodes with tip curvature 0.05 mm is installed on a common axis with tip separation 0.3 mm at the center position of the field. A high voltage pulse of 20 kV, current 50 A, and time width 1.0 $\mu s$ are fired to the electrodes. Experimental apparatus and sequence of operation are identical to those used in Ref. 1). The coils and electrodes are immersed inside a glass Dewar bottle filled with LHe, and light emission between the electrodes is observed through the slit of the silver coated bottle. A collimating lens with bore diameter 60 mm and focal length 92.5 mm on a precision 3-D movable holder is used to focus the light source on the entrance slit with width 0.03 mm of spectrometer (Nikon, G-250). The grating is 1200 grooves/mm, and spectral resolution of the spectrometer is 2.9 nm/mm. Spectral line profiles (350-750 nm) from the spectrometer are observed by the multi-channel detector (Hamamatsu, C4560) with image intensifier of 1024 channels. The master pulse also operates the delayed gate pulse unit (Hamamatsu, C4568) to form delayed signal to open the gate of multi-channel analyzer to observe time-resolved spectral lines at arbitrary delay time $T_d$ after the discharge. Time width of gate pulse is fixed to 0.4 $\mu s$.

In Fig. 1, are shown the Stark broadening of He 587.6 nm line for various $T_d$ after the discharge. At $T_d$=0.5 $\mu s$, the plasma density n=$10^{18}$ $cm^{-3}$, and electron temperature Te=32,000 K. For that period until $T_d$=3.0 $\mu s$, the estimated beta value at the center of the plasma changes from 0.28 to 0.014.

Somewhat surprisingly, no changes in density decays with and without magnetic field can be detected until $T_d$=3.0 $\mu s$ for both mirror and cusp type configurations. An example for the case of mirror type is shown in Fig. 2. We observe decay of total light intensity until $T_d$=18 ms. No differences with and without the magnetic field are detected. Evacuation cooling of LHe to 2.2 K results in no difference. Investigation of the reason is underway.

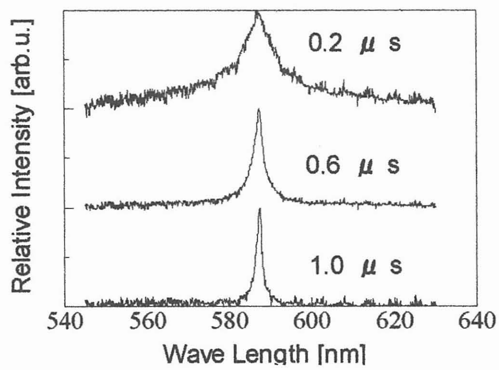


Fig.1 Broadening of He 587.6 nm line.

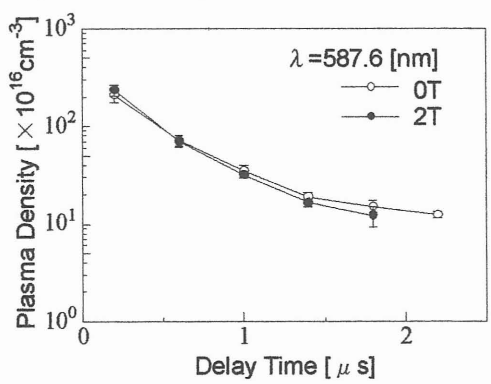


Fig.2 Difference of density decays with and without mirror magnetic field.

1) Qin, W., Minami, K. et al., *Jpn. J. Appl. Phys*. **35**, Part 1, (1996) 4509.