§61. High Density Plasma Target for Beam-Plasma Interaction Experiments

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Interaction of heavy ions with dense plasma is important as a fundamental process concerning the heavy-ion inertial confinement fusion. Enhancement of energy loss of heavy ions in the plasma compared to the cold matter was first predicted by theory many years ago and recently observed by several groups. The enhancement of stopping power is governed by the effective charge state Z_{eff} of the ions. The ions passing through the plasma interact with free electrons so that the effective charge state is determined by the balance of ionization and recombination. Interesting phenomena are expected for a high-density plasma of $n_e > 10^{19}cm^{-3}$ and also for low-energy beams. So it is indispensable to develop the targets of high-density plasma which are available for the in-beam experiments. There are several available beams, namely He to Ar ions of 6 MeV/u and 0.8 MeV/u at HIMAC and H to Cl ions of lower energies from 1.7 MV tandem of TIT.

As the plasma targets we study z-pinch discharge plasma of hydrogen and also laser-induced plasma. The z-pinch plasma target was first constructed by using a Pyrex discharge tube of 17.5 cm in length and 7.5 cm in diameter. The target system is differentially pumped by a mechanical booster pump of 1000 m^3h^{-1} and two turbo molecular pumps. The pumping system is designed to fit to 10^{-6} Torr vacuum of accelerator beam line. Discharge electrodes are excited by a capacitor of 4.4 μF and 100 nH. Initial gas pressure of hydrogen is varied between 0.2 to 0.7 Torr. A typical current of discharge is 30 kA at the charging voltage of 15 kV. The present current is lower by a factor of two compared with the previous experiment using a gas-filled column of 10 cm in length. Behavior of the plasma was observed with a streak camera. The discharge experiments are still at a primitive stage. The plasma must be carefully diagnosed to examine the stability as well as the electron density. Fig.1 shows an example of framing pictures of the target plasma.The electron density is guessed to be the order of $10^{17}cm^{-3}$ based on the previous experiment using the gas filled plasma column where the density was measured as $2x10^{18}cm^{-3}$ at the current of 60 kA.

In order to obtain the denser plasma, the laser induced plasma is studied with a CO_2 laser of 15 J. The ablation is observed to expand to the order of 1 cm with the streak camera. The plasma is to be optically diagnosed. The density gradient is so steep for the irradiation of solid material that foils are planed to be irradiated. The latter method has the advantage of keeping the number density constant at the z axis when the laser light is coaxially guided to the ion beam.

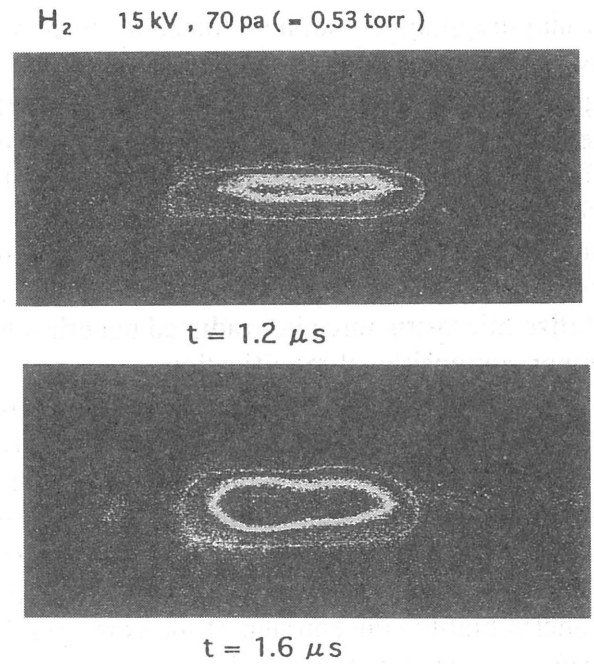

Fig.1 Framing pictures of z-pinch plasma target.