§32. Generation of High-flux Plasma Flow by using Plasma Focus Device and Application of Neutral Particle Measurement

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To demonstrate the stable and long operations for the large helical device (LHD), the measurement of the neutral particles from LHD plasma is required. The information of the neutral particles includes the ion temperature and particle loss in the LHD plasma. Conventional measurement methods for the neutral particles have problems as large scale device and low energy resolution. Recently, a compact measurement method for the neutral particles has been developed, however the calibration of the measurement method was required the large experimental devices. In this study, we develop the generation of high-flux plasma flow by using plasma focus device for the the calibration of the measurement method for the neutral particles.

To generate the quasi-one-dimensional shockwave, we used the taper-cone-shaped plasma focus device [1]. First of all, a creeping discharge occurs between the tapered and the cone electrodes, and a current sheet is generated. The generated current sheet surrounded by the cone electrode is accelerated with the induced magnetic pressure. The accelerated current sheet is pinched at the cone tip, and a kinetic energy of the sheet changes to the thermal energy. The pinched plasma compresses ambient gas, and generates shock wave. The generated shock wave propagates with quasi-one-dimensional behavior in an acrylic tube. In this experiment, to evaluate an effect of magnetic field on the hypersonic plasma flow, permanent magnets, in which size was 3.5 mm, were set on the acrylic tube. The permanent magnets were located at 6.5 mm from the end of the tapered-electrode. An interior of the chamber was filled in the helium gas in this experiment. The distribution of the magnetic flux density in the acrylic tube is shown in Fig. 1.

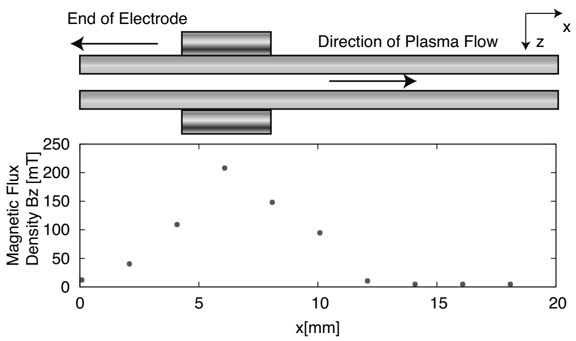

Fig. 1: Schematic image and magnetic flux density distribution in the acrylic tube.

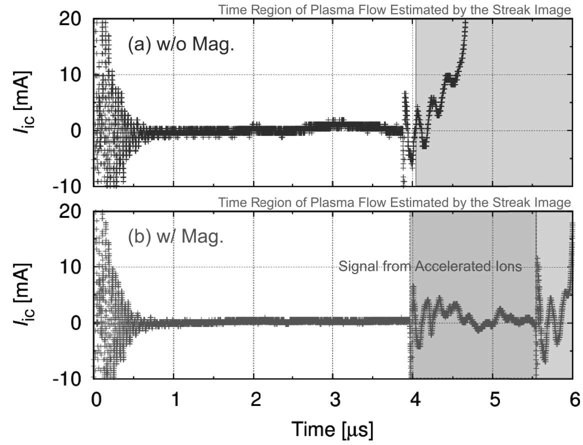

Fig. 2: Ion current I_i measured by the ion collector without or with the magnetic field

Figure 2 shows the ion current I_i measured by the ion collector without or with the magnetic field. To compare the measured ion current with the streak images, we estimated the arrival time at which the ion current was detected by the ion collector. Without the magnetic field as shown in Fig. 2(a), the time of current increase from the ion collector agreed with the plasma flow. On the other hand, with the magnetic field, accelerated ions arriving before the arrival of the main plasma flow were detected as shown in Fig. 2(b). These ions were accelerated after travelling through the perpendicular magnetic field.

Hybrid particle-in cell with this experiments has been demonstrated. The plasma flow decelerated near the peak of the magnetic field, and some ions were accelerated ahead of the plasma flow. The plasma flow observed in the experiment is described by these decelerated ions. The magnetic flux density B_z increased from 25 mT to 50 mT at the front of the decelerated ions. The magnetic field was compressed with the propagation of the plasma flow due to the frozen-in magnetic field at the front of the plasma flow. The plasma flow is decelerated by the enhanced magnetic pressure due to the compressed magnetic field. The electric field E_y, which has the same shape as the magnetic field B_z, was induced. The acceleration mechanism of the ions is a process of converting the kinetic energy of the fluid to kinetic energy of some particles through the electromagnetic fields.

1) T. Sasaki, *et. al.*, JPS Conf. Proc. , (2014) **1**, 015096.