§42-27 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.

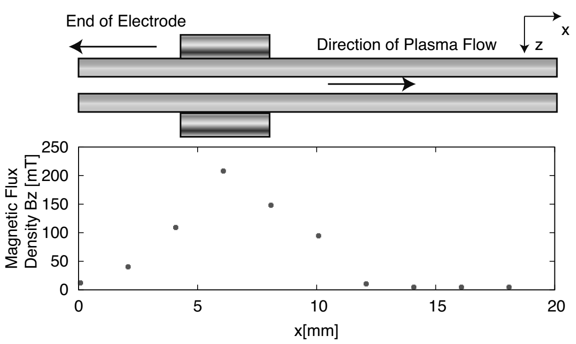

Fig. 1: Schematic image and magnetic flux density distribution in the acrylic tube.

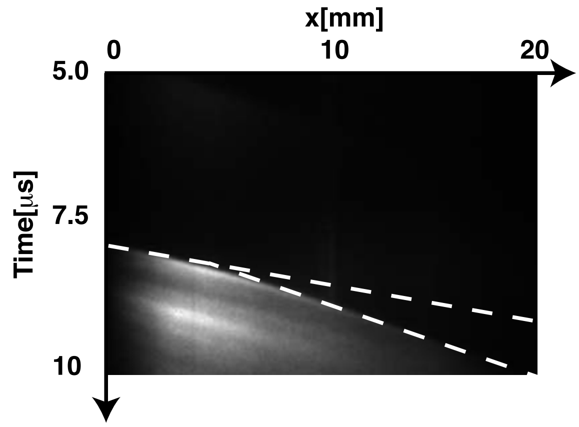

Fig. 2: Streak image of the plasma flow in the acrylic tube with the applied magnetic field at the pressure of 0.6 Pa. [1]

Figure 2 shows a streak image of the plasma flow in the acrylic tube with the applied magnetic field at the pressure of 0.6 Pa [1]. The shock velocity with applied magnetic field decreases from 14.4 km/s to 8 km/s as shown in Fig. 2. The results indicate that the Mach number before the deceleration is estimated to be 14. The pressure and the temperature behind the shock before deceleration are about 90 Pa and 1 eV, respectively. The maximum plasma beta as a peak of magnetic flux density is estimated to be 5.5×10^{-3}. It indicates that the deceleration of the shock occurs in the larger magnetic pressure. After the deceleration, the optical emission at the shock surface increases. It means that the kinetic energy decelerated by the strong magnetic field may change the thermal energy of behind the shock.

Hybrid particle-in cell with this experiments has been demonstrated. The result shows an ion phase space during a perpendicular shock behavior simulated by hybrid PIC at 390 ns. From the comparison of the different perpendicular magnetic field, the fast ions from the behind shock strongly interact the forehand shock in the case of uniform perpendicular magnetic field, and a part of interact ions accelerates from the behind shock. In the case of the triangle perpendicular magnetic field, few accelerated ions are confirmed. It may contribute the ExB drift from the applied magnetic field.

From these results, we confirm the acceleration mechanism generated by the ejected plasma-focus device. To obtain the faster plasma flow, the transmission ratio between the storage energy and the plasma flow is evaluated.

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