§1. High Density Plasma Experiment HYPER-I

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High Density Plasma Experiment-I (HYPER-I) is a linear device, which consists of ten magnetic field coils and a cylindrical vacuum chamber whose dimensions are 30 cm in diameter and 200 cm in axial length (Fig. 1). The plasmas are produced by electron cyclotron resonance (ECR) heating with a 2.45 GHz microwave injected along the magnetic field line from an open end in the high-field side. A high power klystron amplifier (80 kW CW max.) is used for the microwave source, which provides us wide controllability in microwave power input. When the microwave power is relatively low (a few kW), the plasma duration time more than 360 s can be attainable, which is suitable for optical measurements that require long-time averaging for detecting signals. When the microwave power is higher than 15 kW, on the other hand, spontaneous magnetic fluctuations are observed, which makes the HYPER-I device unique as a linear device for basic plasma experiment. Besides the microwave power, the neutral gas pressure can be controlled by mass flow controllers, and the magnetic field strength can be adjusted continuously by the power supply. By setting those three external control parameters appropriately, the HYPER-I device is capable of producing a variety of plasmas to explore various plasma phenomena.

The HYPER-I device also offers powerful diagnostics facilities. Five radial probe-driving systems, which can be readily relocated to different axial positions, and an axial probe-driving system installed on two-dimensionally movable end-flange are available to conduct various probe measurements. In addition, three tunable extended cavity diode laser (ECDL) systems and a pulsed tunable dye laser system have been introduced to carry out absolute flow-velocity measurements of metastable argon neutrals and ions using laser induced fluorescence (LIF) Doppler spectroscopy.

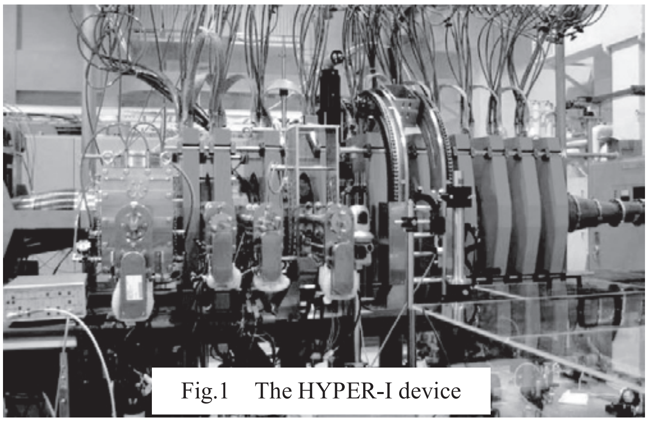

Fig.1 The HYPER-I device

The research activities of the HYPER-I experiment group are mainly focused on the physics of flow and structure formation in plasmas, where a special emphasis is placed on the interactions between neutrals and ions, as well as the development of novel diagnostics. The HYPER-I device provides a unique opportunity to conduct a variety of plasma physics experiments to collaborating researchers and to graduate students.

(i) *Anti-E×B Vortex*

A vortex which rotates in the opposite direction to that of E×B drift has been observed in the deep depletion of background neutrals. The importance of charge exchange interactions between the neutrals and ions on the formation of anti-E×B vortex is proposed. In order to determine the precise neutral flow field, a high-resolution LIF Doppler velocimetry system has been developed, where the Lamb dip appeared in the saturated absorption spectrum is utilized as a frequency standard. The system enables us to measure exceptionally slow neutrals (< a few m/s) associated with the anti-E×B vortex. This is one of the significant achievements in this fiscal year. It should be pointed out that this system can be applicable to ion flow measurement by replacing the ECDL with an appropriate one.

(ii) *Plasma Hole*

A monopole vortex with density cavity in its core, or plasma hole, has been observed in the HYPER-I device, and the flow field has been investigated extensively with directional Langmuir probes (DLPs) so far. In this fiscal year, the LIF system using a pulsed dye laser has been upgraded to be capable of measuring two LIF spectra at different radial positions simultaneously, which contribute to the precision enhancement of the diagnostics and the reduction of measurement time.

(iii) *Plasma Acceleration in Diverging Magnetic Field*

Since the HYPER-I device has a magnetic beach configuration, plasma behavior in a diverging magnetic field can be studied. By combining the DLP and emissive probe measurements, ion acceleration along the magnetic field line has been studied. It is found that spontaneous rotation of ions takes place in accordance with detachment of the ion stream line from the magnetic field line.

(iv) *Development of Novel Diagnostics*

Several experiments for developing novel diagnostics are being underway with the HYPER-I device. (a) Preliminary experiment of helium beam probe has been performed, which aims at application to edge plasma diagnostics in LHD. (b) A pressure sensor (piezoelectric transducer) is tested to detect abrupt pressure change at microwave breakdown. (c) Potential difference formation between two floating electrode is studied to verify the applicability of a face-to-face double probe.