§1. High Density Plasma Experiment HYPER-I

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High Density Plasma Experiment-I (HYPER-I) is a linear ECR plasma device for collaborative research on basic plasma experiment (Fig. 1). The HYPER-I device consists of ten magnetic field coils and a cylindrical vacuum chamber whose sizes are 30 cm in diameter and 200 cm in axial length, respectively. The plasmas are produced by electron cyclotron resonance (ECR) heating with a 2.45 GHz microwave which is injected along the magnetic field from an open end in the high-field side; it allows us to obtain high density plasmas readily without the limitation due to microwave cut-off.

Flexibility of the experimental configurations is one of the strengths of HYPER-I. A high power klystron amplifier is available as the microwave source, which provides a wide range of controllability in microwave power input from 40 W to 80 kW. The pressure and the species of neutral gas can be controlled by mass flow controllers. The magnetic field strength can be varied continuously by the power supply; the magnetic field configuration can be changed by the position of ten magnetic coils. By adjusting these external experimental conditions mentioned above, the HYPER-I device can produce a variety of plasmas to explore various plasma phenomena.

The HYPER-I device also offers powerful diagnostics. Five radial probe-driving systems, which can be relocated to different axial positions, and an axial probe-driving system enable various probe measurements. Two tunable external cavity diode laser (ECDL) systems and a pulsed tunable dye laser system are available to perform laser induced fluorescence (LIF) measurement of metastable argon neutrals and ions.

The research activity of the HYPER-I group covers a broad range of topics. Some of the achievements in this fiscal year are described below.

(i) *Intermittent High-energy Electrons*

Intermittent phenomena are ubiquitous in laboratory, space and astrophysical plasmas. Recently, we have observed spontaneous emission of intermittent high-energy electron fluxes in the HYPER-I device. In order to investigate the spatial distribution and the point of occurrence of the electron flux, we developed a wire-grid probe (WP) which consists of 16 electrodes. By measuring the time series of floating potential fluctuations, the WP successfully reconstructed the spatial distributions of the high-energy electron fluxes. It was also found that the point of occurrence is random in the plasma cross-section.

(ii) *Flow measurement*

Flow measurement using LIF technique is specialty of the HYPER-I group. In order to understand ion flow near an obstacle immersed in a plasma, we conducted LIF measurement using a pulsed tunable dye laser. However, scattered laser light from the obstacle was a nuisance. Suppression of the stray light with double interference filters was attempted in this fiscal year. In addition, the radial distributions of azimuthal flow velocity of plasma hole structure were measured by using two different LIF schemes. As a result, the absolute values of flow velocities obtained by both schemes were in good agreement.

On the other hand, ion flow velocity fields in a diverging magnetic field were measured by a directional Langmuir probe in association with the ion stream line detachment. The plasma starts to rotate in the detachment region, where the radial electric field plays an important role.

(iii) *Development of Diagnostic Method*

Several experiments for developing diagnostic method are being underway. Development of novel plasma spectroscopy utilizing a tunable optical vortex laser is a major challenge which has just begun in this fiscal year. The optical vortex, or the Laguerre-gaussian mode, has orbital angular momentum; it might bring in new feature in plasma spectroscopy.

The effect of secondary electron emission for probe measurement was experimentally investigated using two Langmuir probes of which electrodes are tungsten and molybdenum, respectively. Analytic expression of electron current reduction due to secondary electron emission is given by assuming empirical form of the coefficient of secondary electron emission. The validity of the expression was verified experimentally[1].

1) T. Tawaraya, A. Tsushima, and S. Yoshimura, submitted to Jpn. J. Appl. Phys.

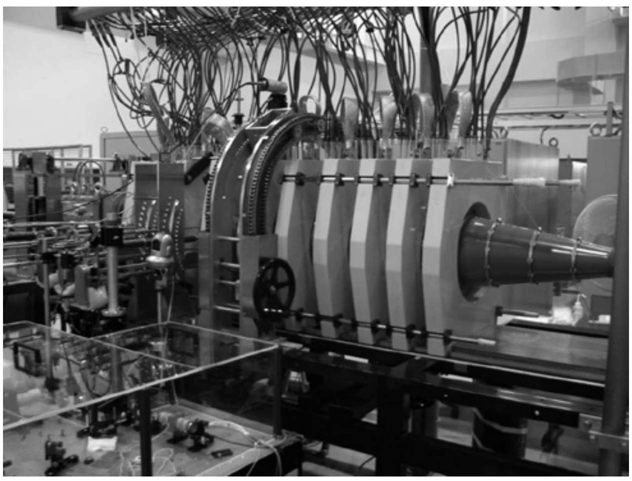

Fig. 1 The HYPER-I Device