§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. 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 available as the microwave source, which provides us a wide controllability in microwave power input. Besides, the neutral gas pressure can be controlled by mass flow controllers, and the magnetic field strength can be varied continuously by the power supply. By adjusting those three parameters, the HYPER-I device can produce 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 the two-dimensionally movable end-flange are available to conduct various probe measurements such as a conventional Langmuir probe, directional Langmuir probe (DLP) and an emissive probe. In addition, three tunable extended cavity diode laser systems and a pulsed tunable dye laser system have been introduced to perform absolute flow-velocity measurement of metastable argon neutrals and ions using laser induced fluorescence (LIF) Doppler spectroscopy.

Although the physics of flow and structure formation in magnetized plasmas has been a major subject since the beginning of the HYPER-I experiment group, our research activity covers a broad range of topics. The HYPER-I device provides a unique opportunity to conduct a variety of plasma physics experiments to collaborating researchers and graduate students.

(i) *Plasma Flow Measurements*

The HYPER-I device can be used to investigate detailed ion flow structure in a diverging magnetic field. In this fiscal year, extensive measurements of ion flow field have been carried out with the DLPs calibrated with LIF spectroscopy. One of the important achievements in this study is the first experimental demonstration of the ion stream line detachment, which takes place in the region of the divergent magnetic field. This result has an impact to the development of plasma propulsion systems.

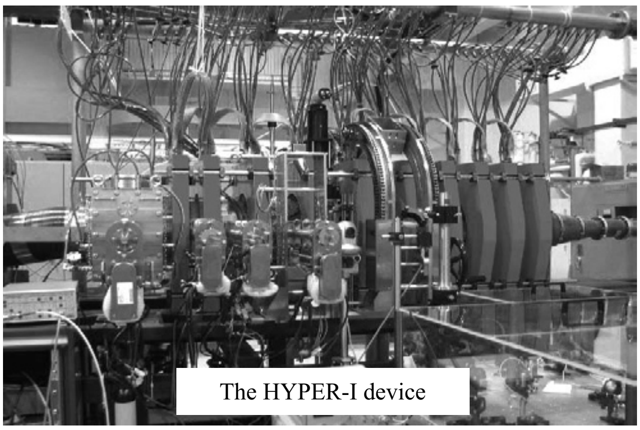
Meanwhile, substantial progress has been made in the LIF measurements. Now the parallel ion flow velocity can be measured without a wavelength standard by using the pulsed tunable dye laser with the quasi-parallel injection method. A high-precision measurement with the ECDL system has also proceeded, which enables us to study a slight asymmetry in the distribution function of neutral particles.

(ii) *Spontaneous Excitation of Magnetic Fluctuations*

Pulsed magnetic fluctuations have been spontaneously excited in the HYPER-I plasma with high microwave power input (>15 kW). The waveform measured with a magnetic (B-dot) probe exhibits a bipolar solitary structure. The dependence of the fluctuations' polarity on radial position implies that an intermittent current induced along the magnetic field line is associated with the excitation mechanism. Further investigations using a high-frequency response Langmuir probe is in progress.

(iii) *Development of Novel Diagnostics*

Several experiments for developing novel diagnostics are being underway with the HYPER-I device. (a) Two dimensional measurement of optical emission spectroscopy with an ICCD camera is being developed. Since the LIF spectroscopy is a local measurement, the capability of obtaining 2D information at once can be a great advantage. (b) A neutral helium beam probe (HeBP) has been developed, which aims at application to edge plasma diagnostics in LHD. The nozzle configuration has improved by adopting the Laval nozzle. The emission profile from the helium beam shows that the Laval nozzle can inject a collimated beam, which is crucial to realize high spatial resolution. (c) A novel probe which tentatively named "reversed Gundestrup type" probe has been developed to measure the potential deformation around biased obstacles in a flowing plasma. The applicability of this method to plasma flow measurement will be evaluated by analyses of the preliminary experiments. (d) Modulation of neutral pressure at microwave breakdown has been observed with a piezoelectric transducer, where the signals whose characteristic frequency was in the order of 10 kHz were detected.



The HYPER-I device