§1. High Density Plasma Experiment HYPER-I

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High Density Plasma Experiment-I (HYPER-I) is a linear device with magnetic fields designed for various basic plasma experiments. Plasmas are produced and sustained by electron cyclotron resonance heating with an electron cyclotron wave (ECW), which is excited by a 2.45GHz microwave launched along the magnetic field line from an open end of the cylindrical chamber. Two microwave sources are available; one is a magnetron oscillator with 15 kW output, and is used for low power experiments. A klystron amplifier with 80 kW output (CW) is also available for high power and high density experiments.

The maximum plasma density is two orders of magnitude higher than the cutoff density of ordinary mode with the same frequency. The characteristic features of HYPER-I plasma are large diameter (30 cm) and high density ($< 10^{13}$ cm^{-3}). A set of probe driving systems was installed in 2001 to measure the flow vector field on a plane perpendicular to the magnetic field. Velocity vector measurements are possible over 80% of the whole plasma cross-section. A tunable dye laser system was introduced in 2003 to develop a laser-induced fluorescence (LIF) Doppler spectroscopy system. The dye laser is excited by a pulsed Nd:YAG laser, and produces 30 pulses per second (max. 100 mJ /pulse) in a range of wavelength 600-630nm. A tunable diode laser system for measuring the flow velocity of background neutrals is under development in collaboration with Nagoya University. The research activities are mainly focused on vortex formation in plasmas, flow velocity measurement using LIF Doppler spectroscopy as well as velocity measurement with asymmetric probes.

(i) vortex formation

A vortex with a cylindrical density cavity in its core (referred to as plasma hole) has been observed, and identified as a viscous vortex such as Burgers vortex. The formation mechanism is studied with emphasis on radial force balance. It is found that in the core region, the centrifugal force dominates the radial electric force, resulting in rigid rotor equilibrium, while in the outer region the plasma rotates with ***E***x***B*** drift . It is also found that the quasi-neutrality breaking takes place in the core region, which is quite exceptional in the sense that it occurs spontaneously over $1000\lambda_D$ scale.

(ii) anti-ExB vortex

Vortical motion in plasmas is usually driven by ***E***x***B*** drift. We have observed a peculiar vortex, which rotates in the opposite direction to the ***E***x***B*** drift. This means that an effective force is present and dominates the electric force. We expect that the effective force may be generated through charge exchange interaction between the plasma and the flow of background neutrals. The preliminary experiments on neutral flow measurement using a tunable diode laser has been started.

(iii) velocity measurement using an asymmetric probe

For the simultaneous measurement of flow velocity, we are developing a new method using an asymmetric probe. This probe detects an unbalanced ion current between two electrodes and provides an easy-to-use method for flow velocity measurement. Development of LIF Doppler spectroscopy using two-photon pumping has also been started.