§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 a same frequency. The characteristic features of HYPER-I plasma are large diameter (30 cm) and high density ($< 10^{13}$ cm^{-3}). In 2001, a set of probe driving systems was installed to measure the flow vector field on a plane perpendicular to the magnetic field. Velocity vector measurements are possible over 80% of the whole cross-sectional area of the plasma. A tunable dye laser system was introduced in 2003 to develop a laser-induced fluorescence (LIF) Doppler spectroscopy. 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, viscosity anomaly, and flow velocity measurement using an asymmetric probe.

(i) vortex formation and anomalous viscosity

A vortex with a cylindrical density cavity (referred to as plasma hole) has been observed, and identified as a viscous vortex such as Burgers vortex. The characteristic feature of viscous vortex is the existence of radial flow, which is driven by the azimuthal velocity shear and finite viscosity. We proposed that effective viscosity can be determined by measuring the radial flow velocity and azimuthal velocity shear. The preliminary experiment was carried out and revealed that the effective viscosity is at least 2 orders of magnitude higher than the classical estimation.

(ii) anti-ExB vortex

Usually, vortical motion in a plasma is driven by the ***E***x***B*** drift. We have observed a peculiar vortex, which rotates to the opposite direction to the ***E***x***B*** drift. It is found that this vortex always accompanies with a deep density hole in the background neutrals. If the charge exchange process is dominant, a net momentum exchange between the neutral flow and plasma may drive the anti-***E***x***B*** rotation. We are now developing a LIF system using a tunable diode laser to detect the flow of neutrals.

(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. The dye-laser LIF Doppler spectroscopy will be used for the calibration of this probe.