§15. Flow Field Measurement of Neutrals Using a Single-mode Tunable Diode Laser

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Rotating flow in a magnetized plasma is usually driven by ***E***x***B*** drift. However, a vortex with anti-***E***x***B*** rotation has been recently found in the HYPER-I device. This result strongly suggests that there exists a force acting on the ions, which dominates the ambipolar electric field. It is of very much importance to reveal the underlying physics of anti-***E***x***B*** rotation, from the viewpoint of fundamental plasma physics and of understanding dynamical behavior of confined plasmas in the surface regions. The purpose of this collaborative research is to clarify the formation mechanism of the anti- ***E***x***B*** vortex.

Spectroscopic measurements show that the anti-***E***x***B*** vortex always accompanies with a deep density hole in the background neutrals. This reminds us of existence of neutral flow due to steep density gradient. Momentum transport between neutral flow and ions, through charge exchange collisions is probably the origin of the force, which should be verified by measuring the neutral flow.

To measure the neutral flow field, we have to adopt a laser-induced fluorescence (LIF) Doppler spectroscopy, but it has not been well established so far. Major difficulty of the LIF Doppler spectroscopy for neutral flow is the accuracy of frequency determination. Since the flow velocity of neutrals is supposed to be of the order of several tens m/sec, the corresponding Doppler shift is of the order of 10 MHz ($\Delta f/f=10^{-7}$). To develop a high precision LIF system, the laser spectrum should be less than a few MHz, which can be realized by using a tunable diode laser.

Figure 1 shows the schematic diagram of our LIF Doppler spectroscopy system. A laser light (696.735nm) from a diode laser is modulated by an Electro-Optical modulator with a frequency of 100 kHz, and is introduced into the vacuum chamber. Metastable argon neutrals ($3s^23p^5(^2P^o{}_{3/2})$ 4s) are excited to an upper level ($3s^23p^5(^2P^o{}_{1/2})4p$), and the deexcitation photons (826.45nm) are detected by a photomultiplier tube (PMT) and a lock-in amplifier. An iodine cell is introduced into the system, and the absorption spectrum near the laser wavelength is measured as a wavelength reference.

To confirm the existence of target metastable atoms, we took the absorption spectrum of the plasma.

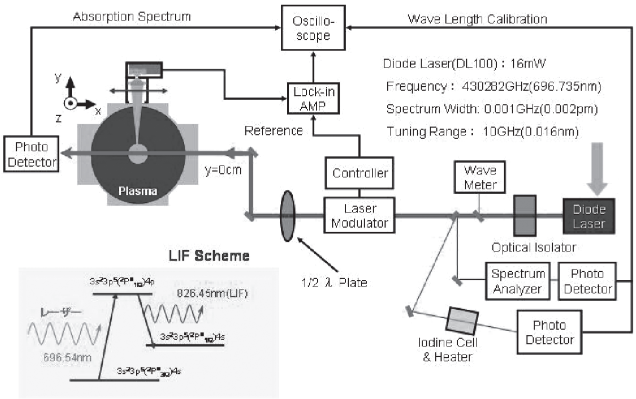

Fig.1 Schematic diagram of LIF Doppler spectroscopy system

Figure 2 shows the LIF spectrum for a plasma produced by low power microwave (40W), in which there are sufficient number of metastable atoms in the plasma. The LIF spectrum shown in Fig.2 are well fitted by a Gaussian distribution curve with a temperature of 0.03eV(350K). This well agrees with the expected value. The peak intensity of LIF spectrum increases with the laser power, and does not saturate up to 7.3 mW.

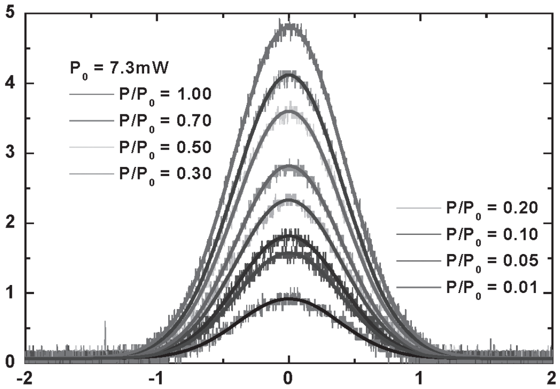

Fig.2 LIF spectrum as a function of laser power.

When the anti-***E***x***B*** vortex is present in the plasma, which is produced with a 5kW microwave, the LIF signal remarkably decreases because of collisional loss of lower metastable atoms and increase in collisional deexcitation of upper level atoms.

To raise the system performance, we have improved the photon collection optics and also introduced a high frequency lock-in amplifier (SR844) A preliminary experiment shows a good signal to noise ratio.