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

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Vortical flow in magnetized plasmas is usually driven by ***E***x***B*** drfift. Recently, a vortex with anti-***E***x***B*** rotation has been found in the HYPER-I device. This result suggests that there exists a force acting on the ions, which dominates the electric field. It is of very much importance to reveal the underlying physics of generation of anti-***E***x***B*** rotation, from the viewpoint of fundamental plasma physics and of understanding dynamical behavior of boundary plasmas.

Spectroscopic measurements show that the anti-***E***x***B*** vortex always accompanies with a deep density depletion in the background neutrals. Then the neutral flow due to steep density gradient is supposed to play an important role on generation of the vortex i.e., momentum transport between ions and neutral flow may produce the dominant force through the charge exchange collisions. Since neutral flow velocity is generally slow (~10m/sec), the precise measurement has not been done so far.

We have developed a high resolution laser-induced fluorescence (LIF) system using an external cavity diode laser (ECDL). Major difficulty of LIF Doppler spectroscopy for slow neutrals is the accurate determination and controll of the laser wavelength. Since the Doppler shift corresponding to a flow velocity of 10 m/sec is of the order of 10 MHz ($\Delta\lambda/\lambda=10^{-7}$), it is essential to adopt a well controlled tunable diode laser. An ECDL meets this requirements.

A diode laser (λ = 696.735nm) is used to excite metastable argon neutrals ($3s^2 3p^5 (^2P^o_{3/2})$ 4s) to an upper level ($3s^2 3p^5 (^2P^o_{1/2})$4p), and the deexcitation photons (826.45nm) are detected by a collection optics and a photomultiplier tube . To improve the signal to noise (S/N) ratio, an electro-optical device is introduced to modulate the laser beam with a frequency of 100kHz. The LIF signal is detected by a lock-in amplifier. An iodine cell is also introduced to the system, and the absorption line near the laser wavelength is used as a wavelength reference. Figure1 shows the newly developed LIF system

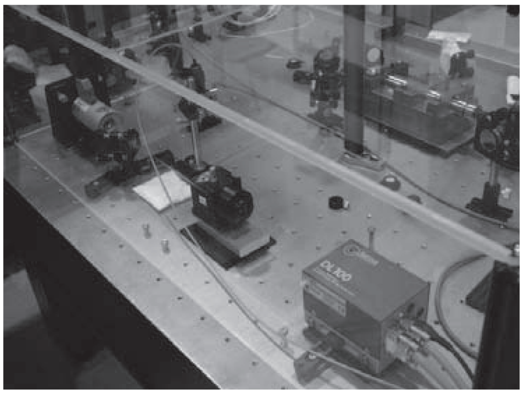

Fig.1. High resolution LIF system

By changing the laser wavelength, we obtained the LIF spectrum, which is proportional to the distribution function of neutrals. The temperatures of neutrals were 0.034eV for low power operation, and 0.1eV for high power operation. From the Doppler shift of the distribution function, we determined the flow velocity. The radial profile of neutral flow velocity is shown in Fig.2. There is an inward flow of neutrals with the maximum velocity of 70m/sec. When the anti-***E***x***B*** vortex is present in the plasma, the ion radial flow is directed to outward, and the relative velocity is 0.2 ~ 0.3Cs, where Cs is the ion sound velocity. In this condition, the momentum transfer due to charge exchange collisions is so enough that the resultant force dominates the electric force.

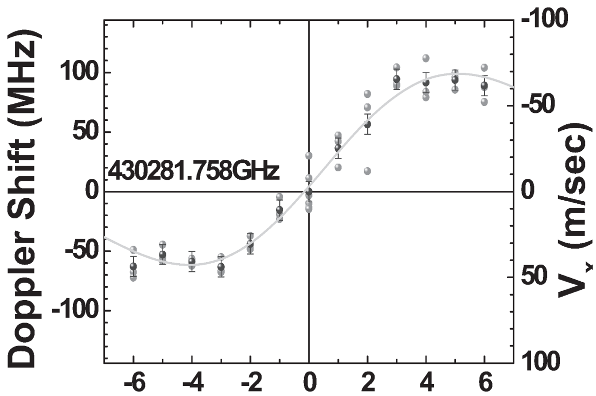

Fig.2. Radial flow profile (inward flow).