§4. Measurement of Flow Velocity Profile in a Plasma Hole using Laser-Induced Fluorescence

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Local measurement of flow velocity is required for researches on plasma interaction with boundaries, transport physics, and non-linear plasma structure. One of vortical structure, the "Plasma Hole," observed in an ECR plasma has eccentric feature; a supersonic ***E***×***B*** rotation is caused by a strong radial electric field.[1] As shown in Fig. 1, the plasma hole is observed as a dark region in a visible image, where the density is one-tenth of that of the ambient plasma. Thus, measurements of flow velocity and density of both ions and neutrals are required for complete understanding of the vortex formation. Because flows of our interest are sometimes supersonic or related to neutral particles, a direct method of absolute velocity measurement, which complement to directional Langmuir probe (DLP) methods, is needed. Laser induced fluorescence (LIF) has the advantages of both spatial resolution and absolute velocity measurement.

The experiments were performed in the HYPER-I device at the National Institute for Fusion Science.[2] A plasma hole is spontaneously formed in an argon plasma and is maintained stationary during 200s of the discharge-duration time. Azimuthal and radial components of flow velocity-field in the plasma hole were measured using LIF Doppler spectrometry.[3] A tunable dye laser excited by a Nd:YAG laser was used. In the present experiment, laser wavelength is tuned to 611.5 nm, which excites an Ar II metastable state (3d $^2G_{9/2}$ - 4p $^2F_{7/2}$). The laser light is transferred with mirror optics and injected into the plasma. The laser-induced fluorescence from argon ion, which is de-excited spontaneous emission of wavelength, 461.0 nm (4s $^2D_{5/2}$ - 4p $^2F_{7/2}$), is collected by a collimating lens, and is detected by a photomultiplier tube through an interference band-pass filter. The output signal is integrated with a boxcar integrator synchronized with the laser pulse. The laser wavelength is scanned in a range of 0.05 nm during a 200 s discharge. Then a component of flow velocity in a position is obtained from the Doppler shift of the LIF spectrum.

By changing injecting beam path of the laser, we can measure the radial profile of the rotation (azimuthal) velocity of the argon plasma hole. The plasma rotates rigidly in the hole region as shown in Fig. 2, direction of which is the same as that of the *E*×*B* drift.[4] On the other hand, the radial profile of the radial velocity component is measured by changing the observation line of sight. The result shows a slow outward flow in the hole region, implying the direction of the radial flow is differ from that observed in helium plasma holes. Detail investigation will be performed in our future work.

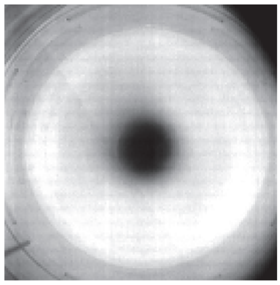

Fig. 1 A visible light image of Plasma Hole, where the diameter of a dark core is 70-80 mm.

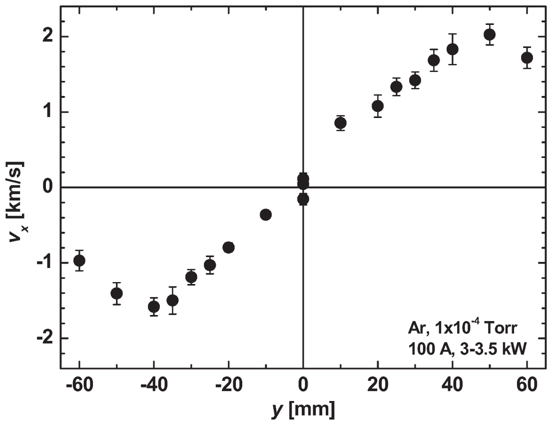

Fig. 2 Azimuthal velocity distribution of argon ion measured by LIF.

1) Nagaoka, K. et al. : Phys. Rev. Lett. **89** (2002) 075001, Tanaka, M.Y. et al. : IEEE Trans. Plasma Sci., **33** (2005) 454
2) Tanaka, M. et al. : J. Phys. Soc. Jpn. **60** (1991) 1600
3) Okamoto, A. et al.: J. Plasma Fusion Res., **80** (2004) 1003
4) Yoshimura, S. et al. : Plasma Fusion Res. SERIES **6** (2004) 610