§4. Stray Light Suppression for LIF Measurement around a Cylindrical Obstacle

Okamoto, A. (Tohoku Univ.), Tanaka, M.Y. (Kyushu Univ.), Yoshimura, S.

Understanding of flow velocity field near an obstacle is an interesting topic in the research field of plasma-surface interaction as well as basic plasma physics. using a flow passing by an obstacle, a viscosity of plasma would be determined. Probe theories applicable to ion flow measurement especially in the supersonic flow can be improved by the help of the detailed flow field around the probe.[1] That permits direct comparison with the viscosity of ordinary fluid. While some simulation results are reported,[2] experimental approach should be intensively conducted. Then the measurement method that does not disturb the plasma flow itself and that enables us to obtain local flow velocity is required.

We have developed such the measurement method using the laser induced fluorescence (LIF) technique.[3] Different from bulk plasma measurements, the measurement near a boundary surface is a hard work due to the undesired scattered light of intense laser. In this report, suppression of the scattered laser light in LIF measurement near a cylindrical obstacle is described.

The experiments were performed in the HYPER-I device at the National Institute for Fusion Science.[4] An argon plasma was produced by the electron cyclotron resonance of a 2.45 GHz microwave injected from the high field side along the magnetic field. In the present experiment, parallel flow of ion in the diverging magnetic field region[5] was measured using the quasi-parallel LIF Doppler spectroscopy.[6] In order to avoid stray lights, the three level scheme is chosen. The dye laser wavelength is tuned to 611.5 nm, which excites a metastable argon ion ($3d\ {}^2G_{9/2} - 4p\ {}^2F_{7/2}$). The laser-induced fluorescence (461.0 nm, $4s\ {}^2D_{5/2} - 4p\ {}^2F_{7/2}$) from the argon ion is collected and is detected by a photomultiplier tube through an interference band-pass filter. Pass band and blocking of the interference filter are 1 nm and 10^{-4}, respectively.

Experimental setup is shown in Fig. 1. A cylindrical obstacle (x-direction) is installed perpendicular to the magnetic field (z-direction) in the center of a downstream port. Diameter and length of the cylindrical obstacle are $a = 1$ cm and $l = 14$ cm, respectively. Assuming the ion temperature $T_\mathrm{i} \simeq 1$eV, Larmor radius satisfies $a < \rho_\mathrm{i} < l$. The laser is in the quasi-parallel direction to the magnetic field. Height of the laser path is 1 cm apart from the surface of the cylindrical obstacle. The fluorescence is collected along a line of sight from a port perpendicular to both the magnetic field and the cylindrical obstacle. Observation volume of the LIF is about 1 cm in x direction, 0.5 cm in y direction, and 3 cm in z direction, respectively.

The LIF spectrum is shown in Fig. 2. As plotted by open triangles, the spectrum contains a wavelength independent offset. The offset comparable to the peak height of a true LIF signal disappears when the cylindrical obstacle is retracted. A leak in the laser wavelength due to scattering of halo on the surface of the obstacle is a possible cause of the offset. Doubling the interference filter the offset is reduced to one order smaller value as plotted by filled circles. Peak height reduction is the same as that expected from the passband transmission of the filter suggesting high signal to noise measurement even in lower density conditions.

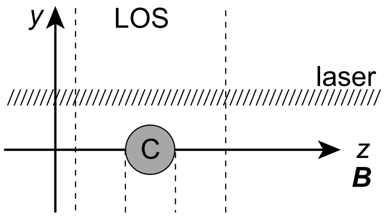

Fig. 1: Schematic of the experimental setup. LOS and C represent a fluorescence-collecting line of sight and a cylindrical obstacle, respectively. The external magnetic field is in z direction.

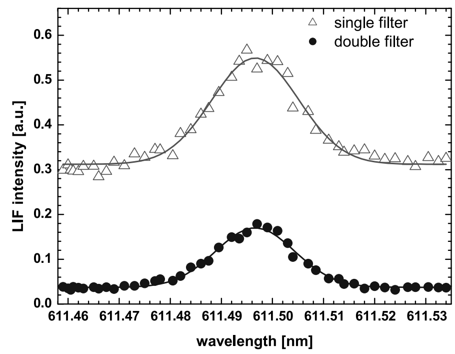

Fig. 2: LIF spectra. Open triangle is obtained with a interference filter. Filled circle is obtained with the filter doubled.

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3) Okamoto, A. et al. : J. Plasma Fusion Res. **80** (2004) 1003.

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5) Terasaka, K. et al. : Phys. Plasmas **17** (2010) 072106.

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