§3. Development of Two-Photon Absorption Laser-Induced Fluorescence for the Measurement of Helium Ion and Atom

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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, "Plasma Hole," observed in an ECR plasma has eccentric feature; supersonic $\boldsymbol{E}\times\boldsymbol{B}$ rotation is caused by a strong radial electric field. [1] Density of the plasma hole is one-tenth of that of 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 neutral flow and supersonic ion flow, 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.

After measurement of argon ion velocity in an ECR plasma, [2] we have started to develop a LIF scheme for combined measurement of helium ion and helium atom.

In order to suppress stray light caused by laser scattering at windows, the wavelength of the fluorescence is preferably differ from that of the laser. On the other hand, increasing a ratio of the LIF signal to noise of the background plasma emission, larger population density of initial state is important. Candidates of such optical transitions in helium ion are shown in Fig. 1 (a). A laser light tuned to 640.62 nm is absorbed in an excited state of helium ion (n=3) by two-photon absorption process. Then fluorescence of 320.31 nm is emitted from the intermediate excited state (n=5). Although only two energy states are related to this LIF scheme, two-photon absorption process enables us to distinguish the fluorescence from the stray light. Another scheme is also available, where near-infrared laser (1012.36 nm) is used to excite a n=4 state to the n=5 state. However the former scheme has the advantage in population density of the initial state.

LIF scheme using two-photon process for helium atom is also considered, in which transition from a metastable state (2 ^3S) [3] is used as shown in Fig. 1 (b). The laser wavelength is tuned to 632.96 nm corresponding to transition to a 4 ^3D state. Fluorescence of the wavelength 447.15 nm (2 ^3P - 4 ^3D) is observed. The laser wavelength for excitation of the helium ion and the helium atom are available using the same dye and the same laser transmission optics.

The experiments were performed in the HYPER-I device at the National Institute for Fusion Science.[4] A tunable dye laser excited by a Nd:YAG laser was used. The laser light is transferred with mirror optics and injected into the plasma. The laser-induced fluorescence from helium atom 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.

Although the higher S/N ratio than present measurement is required for quantitative discussion on the flow velocity and density distributions, the LIF signal was measured. These results show that two-photon absorption LIF spectroscopy is a promising tool for local and absolute measurement of flow velocity of both ions and neutrals.

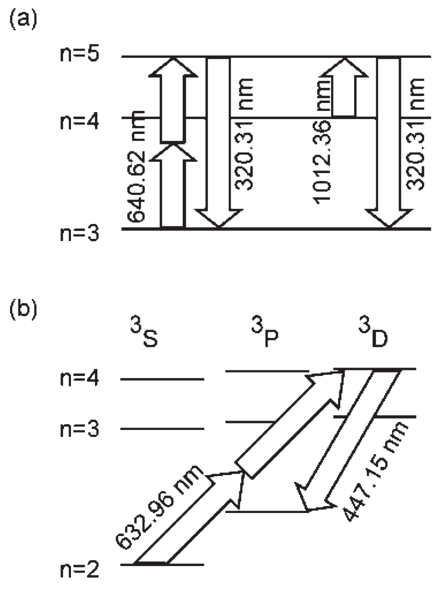

Fig. 1 Energy level diagram of (a) helium ion and (b) tripret state of helium neutral.

Reference
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