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高密度ヘリコンプラズマによる完全無電極電気推進の研究(V)：2 次元 LIF 計測の開発

Study on Completely Electrodeless Electric Propulsion System using High-Density Helicon Plasma (V): Development of 2D LIF Measurement

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An electrodeless plasma thruster is an advanced space propulsion concept suitable for a long-time space mission. However, a lifetime of most present system is limited due to electrode erosion and contamination by plasmas. To overcome this problem, we are proposing a new electrodeless electric propulsion system with a high efficiency and a long lifetime as the Helicon Electrodeless Advanced Thruster (HEAT) project [1]. This scheme employs a high-density (~10^{13} cm^{-3}) helicon plasma accelerated by the Lorentz force, which is the product of the azimuthal current j_θ induced in the plasma and the radial, external magnetic field B_r [2].

To prove its principle, it is also important to measure a plasma flow, ion temperature and its density. Laser Induced Fluorescence (LIF) is a powerful tool for plasma diagnostics, due to a non-invasive method with a high spatial resolution. It can deduce velocity distribution functions of any particles (ions, atoms and molecules).

Here, we will report experimental results of argon Ion Velocity Distribution Functions (IVDF) in the high-density helicon plasma in Large Mirror Device (LMD) [3]. For an argon ion, we used a three state LIF scheme, in which ArII $3d^4F_{7/2}$ metastable state is optically pumped by 668.16 nm (in vacuum) laser light to $4p^4D_{5/2}$ state, which decays to $4s^4P_{3/2}$ state with an emission at 442.60 nm [4]. Figure 1 shows a LIF system on LMD. The fluorescent emission was collected by a focus lens and optical fiber cable, and then it passed through a 4 nm bandwidth interference filter to reach a high-gain photomultiplier tube (PMT). We employed a Fast Fourier Transform (FFT) method to obtain the LIF signals modulated with laser chopped frequency by Electro-Optic Modulators (EOM).

We have developed new 2D LIF system with a scan region of z = -10 ~ -50 cm and r = 1 ~ 8 cm. Figure 2 shows examples of two IVDFs of axial component measured at two different points. These temperatures and their velocities derived are ~ 0.50 eV and ~ 1,150 m/s at z = -10.3 cm, ~ 0.48 eV and ~ 2,480 m/s at z = -21.8 cm, respectively. More detailed measurements of 2D IVDF along with the neutral particle velocity distribution function will be presented at the conference.

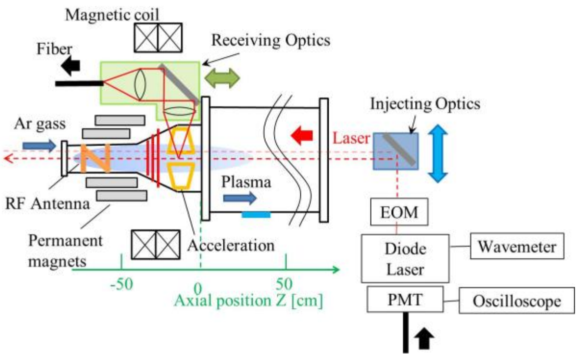

Fig. 1 LIF system on LMD.

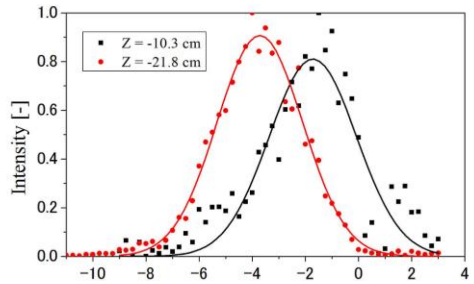

Fig. 2 Derived IVDF by LIF.
(RF power P_{RF} = 2 kW, magnetic field B_z = 300 G and Ar gas Pressure = 4.6 mTorr)

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