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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(Ⅳ)：2 次元分光計測

Study on Completely Electrodeless Electric Propulsion System Using High-Density Helicon Plasma (IV): 2D Imaging by Spectroscopic Method

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An electric propulsion is known as an efficient method suitable for deep space explorers. However, most electric propulsion methods have electrodes contacting directly with plasma, and its lifetime is limited by electrodes' erosion. In order to overcome this problem, we have been developing an electrodeless electric propulsion system, using a helicon discharge [1] and electrodeless acceleration, e.g., Rotating Magnetic Field [2] acceleration. Since plasma diagnostics is important for demonstrating this acceleration method and improving its performance, we have carried out optical measurements by using a high-speed camera, a high wavelength resolution monochromator and a CCD monochromator. They can measure many kinds of plasma parameters invasively.

The high-speed camera, FASTCAM SA-5, Photron (1.3 Mfps, 1,024 × 1,024 pixcels) uses interference filters which can select emissions from neutral Ar particle (ArI) and singly-charged ion (ArII). If electron temperature is uniform and electron impact excitation is dominant, intensities of ArI and ArII are proportional to $n_e n_0$ and n_e^2, respectively (n_e: electron density, n_0: neural particle density). Since the emission taken by the high-speed camera is a projection, we have performed asymmetric Abel inversion and Algebraic Reconstruction Technique (ART) to take a local emission profile. Figure 1 shows n_e profiles derived by the high-speed camera and a Langmuir probe methods, showing a good agreement between ART and the probe.

The CCD monochromator, HR2000+, Ocean Optics, (resolution: 0.5 nm) can measure a wide range of spectra of the emissions (360 nm-792 nm). By selecting proper spectral lines, an electron temperature and n_e can be derived by using intensity ratio on collisional radiative model [3]. The high resolution monochromator, Czerny-Turner type MC-150, Ritu Oyo Kougaku Co., Ltd. (wavelength range: 190~600 nm, grating: 2,400 lines/mm, resolution: 0.006 nm) has enough resolution to take an ion velocity, an ion temperature and a neutral temperature in our experiment. Figure 2 shows an example of ion Doppler shifts measured by the high resolution monochromator, corresponding to the plasma flow velocity of 2,000 m/s.

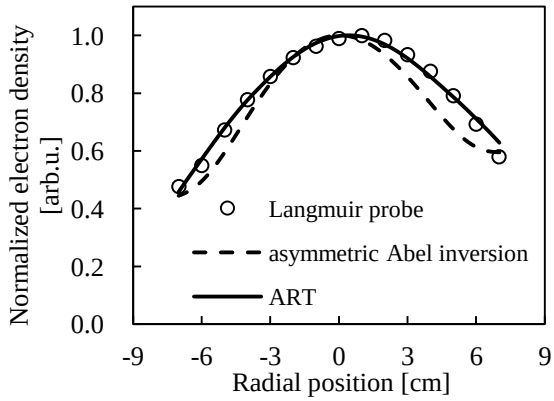

Fig. 1. Normalized electron density profiles.

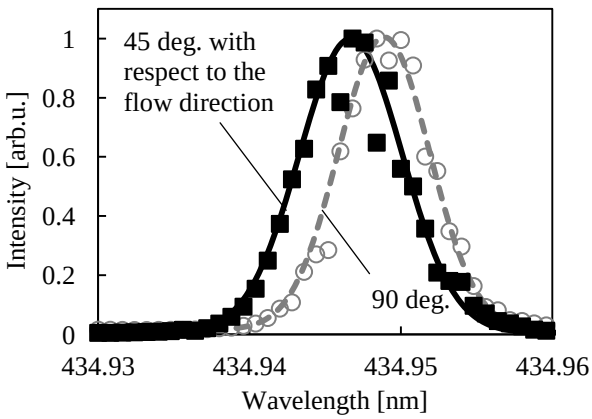

Fig. 2. Doppler shifts by a monochromator.

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