§6. 2-D Optical Emission Spectroscopy in the HYPER-I Device

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In highly ionized plasmas, electron pressure can be comparable to neutral gas pressure. Self-organized structures of plasma and neutral gas are generated by the interaction among the electrons, ions and neutral atoms in such plasmas. Flow of particles is driven by the spatial structure of particles. Therefore, the effect of the flow should be taken into account in the pressure balance of nonuniform plasmas. The total pressure p_{Total} is defined as follows:

$$p_{\mathrm{Total}} = p_{\mathrm{S}} + p_{\mathrm{D}} ,$$

$$p_s = kTn ,$$

$$p_d = \frac{1}{2}\rho v^2 ,$$

where p_{S}, p_{D}, k, T, n, ρ, and v are static pressure, dynamic pressure, Boltzmann constant, temperature, number density, mass density, and flow velocity, respectively. The balance of p_{Total} is important in determining the dynamics of nonuniform plasmas. Therefore, measurements of the flow velocity, temperature and density distribution of ions, electrons, and neutrals are fundamentally important.

We are studying the formation of anti-$\boldsymbol{E}\times\boldsymbol{B}$ type vortexes which have been found in the high density plasma experiment (HYPER-I) device at the National Institute for Fusion Science. The plasma is generated by electron cyclotron resonance (ECR) heating. Localization of plasma and depletion of neutral gas around the centre of a cylindrical vacuum chamber were found by preliminary experiments so far. The momentum transfer between ion flow and neutral gas flow generated by the neutral gas structure is considered to play an important role in the formation mechanism of the anti-$\boldsymbol{E}\times\boldsymbol{B}$ type vortexes. We have observed the neutral flow[1-4] which is induced by the neutral-gas depletion sustained by electron pressure. The observed 2-D neutral gas flow field was consistent with our model of the anti-$\boldsymbol{E}\times\boldsymbol{B}$ type vortexes generation. This study aims at performing 2-D optical emission spectroscopy of the ECR plasma using an image intensified CCD (ICCD) camera. The spatial distribution of neutral atoms, ions, and electrons will be obtained by analyzing the optical emission images using a collisional–radiative model (CRM) and the results of laser induced fluorescent (LIF) measurements. By combining the 2-D particle distribution measurements with 2-D flow field measurements, the deeper understanding of the mechanism of the anti-$\boldsymbol{E}\times\boldsymbol{B}$ type vortexes generation will be gained.

The sizes of the HYPER-I vacuum vessel are 30 cm in diameter and 200 cm in axial length. Plasma is generated by ECR heating. The power of microwave was 5 kW at 2.45 GHz. The argon gas pressure was 1.0×10^{-2} Torr. Optical emission is observed from the end viewport of the cylindrical vacuum vessel. The 2-D optical spectroscopy will be performed using an ICCD camera equipped with an interference filter. This year, we tested an imaging system for the ICCD camera, and performed a preliminary optical emission measurement using a USB spectroscope. Figure 1 shows the optical emission spectra of the ECR Ar plasma. The CRM analysis of optical emission spectra observed in a similar plasma has been reported （D. L. Crintea, et al, J. Phys. D 42 (2009) 045208）. We expect that the same method can be utilized, since the all spectra which were used the CRM were observed in Fig. 1. We will begin the 2-D optical emission measurement from the next fiscal year.

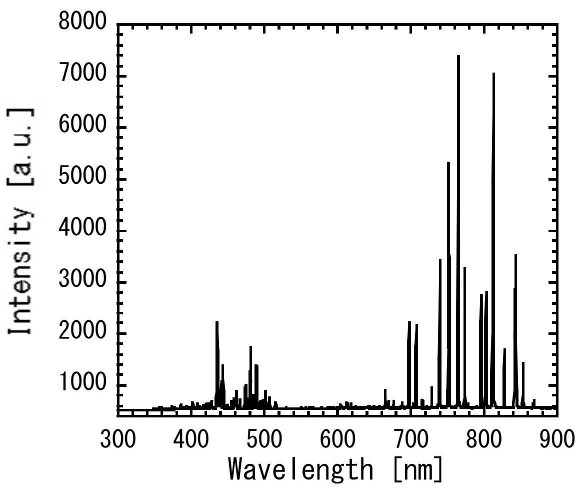

Fig. 1 Optical emission spectra observed in the HYPER-I device.

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