§5. Observation of Neutral Particle Distributions in a Plasma Vortex Using a Few Lines of Sight of Visual Light

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In plasmas, various vortical structures are formed depending on experimental conditions. Mechanisms on their formation are physically interesting and attracting. It is reported that such vortical structures are formed in the HYPER-I device of National Institute for Fusion Science. The vortex shows several variations when strength of magnetic fields of the device, gas pressure, and injecting power of microwaves are tuned properly. A lot of investigations on the structures have been reported.1,2) A purpose of the present work is to observe the density distributions of ions and neutral particles in the vortical structures using a few lines of sight of visual light, a non-contact observation, without disturbing plasma.

Experiments were carried out using the HYPER-I device. Argon gas was used at a pressure of 1.8×10^{-2} Torr, and a flow rate of 0.39 sccm. An electric current applied to each magnetic coil to induce a magnetic field was 115.8 A. A microwave was injected at a power of 9 kW. Under these experimental conditions, a vortex with a "single-eye", where there is a bright part of relatively strong emission of the visible light, is formed at a center of a cross section of the device along the chamber axis. To observe the neutral particle distribution at a cross section of the device, two lines of sight, horizontal (x) and vertical (y) directions, are adopted. These lines of sight detect the strength of visible light from the vortex with wavelengths 425.9 nm from neutral particles (ArI) and 488.0 nm from monovalent argon ions (ArII). From the detected strength of the visible light at each position of the detector, spatial profiles of the strength of the emission are obtained. The neutral particle distribution is reconstructed using the spatial profiles with Abelian transformation method.

On the basis of these obtained profiles, spatial density profiles of the ion and neutral densities are estimated using equations, $n_i \propto \sqrt{I_i}$ and $n_n \propto I_n / \sqrt{I_i}$, where n_j and I_j denote the density and intensity of the emission of j (= i for ion and n for neutral particle) species, respectively. The spatial density profile of the ions and neutral particles are shown in Fig. 1 and 2. It is hard to find a huge difference in the horizontal and vertical distributions on both cases of the ions and neutral particles. It is also found that the ion density approximately distributes uniformly or shows a small convex in space. On the other hand, the neutral density shows a concave distribution. This means that the ion density is slightly high and the neutral density is low at the bright part around the center of the vortex.

In summary, the density distributions of ions and neutral particles in the vortical structures using a few lines of sight of visual light are obtained. This method is a non-contact observation. Plasma and the vortex structure are never disturbed by the observation. It will be clarified that a role of neutral particles for the vortical structure formation in near future.

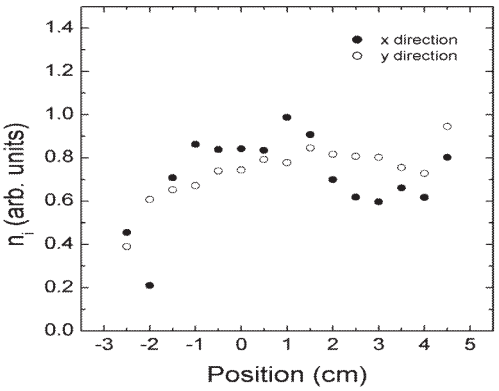

Fig. 1. The spatial density profile of ions.

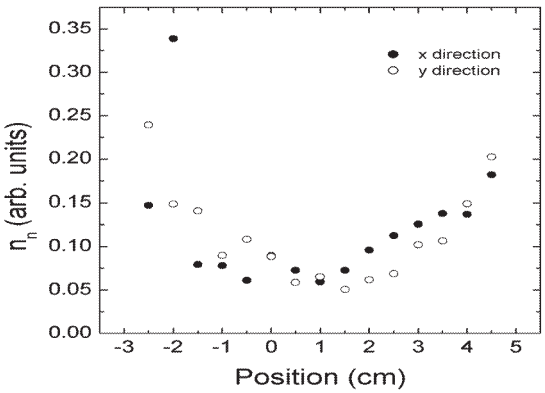

Fig. 2. The spatial density profile of neutral particles.

References

1) A. Okamoto, K. Nagaoka, S. Yoshimura, J. Vranješ, S. Kado, M. Kono, and M. Y. Tanaka, IEEE Trans. Plasma Sci. **33** (2005) 452

2) M. Y. Tanaka, K. Nagaoka, A. Okamoto, S. Yoshimura, and M. Kono, IEEE Trans. Plasma Sci. **33** (2005) 454