§2. Self-Consistent Particle Flows in a Plasma Coherent Structure

Hasegawa, H., Ishiguro, S.

Recently, in magnetic confinement fusion device experiments, it has been observed that plasma spreads to the farther scrape-off layer (SOL) although the exponential distribution is expected from a diffusion model[1]. Motivated by such experiments, some theoretical and computational researches about fusion peripheral plasmas have been made. Then the theory of plasma blob dynamics has been proposed as the mechanism of the convective radial transport[2]. The plasma blob is an intermittent filamentary coherent structure along the magnetic field line. The electric field is induced by the grad-B or curvature drifts in such a coherent structure and the structure moves from the edge of core plasma to the first wall by the ExB drift. Many authors have investigated dynamics of blob propagation on the basis of two-dimensional reduced fluid models[3]. In such kind of macroscopic models, however, microscopic effects (such as sheath formation between plasma and divertor plate, velocity difference between ions and electrons, and so on) are considered under some assumptions and treated as some empirical parameters. Thus, in this study, we study blob dynamics with the first principles method (that is, a three dimensional electrostatic plasma particle simulation[4, 5]) without empirical models.

In our simulations, an external magnetic field is pointing into the z direction (corresponding to the toroidal direction). The strength of magnetic field increases in the positive x direction (corresponding to the counter radial direction) as $2\ L_x\ B_0\ /\ (3\ L_x - x)$ where L_x, L_y, and L_z are the system size in the x, y, and z directions and B_0 is the magnetic field strength at $x = L_x$. Particle absorbing boundaries are placed at $x = 0$ and in the both ends of z axis. The plane at $x = 0$ and others at $z = 0$ and L_z correspond to the first wall and divertor plates, respectively. Periodic boundary condition is applied in the y direction (corresponding to the poloidal direction). A blob is initially located as a column along the ambient magnetic field. The initial density configuration of a blob in the cross section is given by the Gaussian distribution with the width δ_b.

In our previous study, we found the self-consistent spiral electric current system in a blob (See Fig. 1). In this fiscal year, we have studied particle flows which form the current system and observed their velocity distributions. Figure 2 shows the distributions of electron and ion flows in the z direction. In this figure, the blob lies at $y\ /\ \rho_s \sim 30.98$. Figure 2 indicates that the y position of the ion flow peak is different from that of the electron. This difference arises from the potential structure in a blob and induce the current in the z direction. Furthermore, the special properties of velocity distributions which are also caused by the potential structure have been observed.

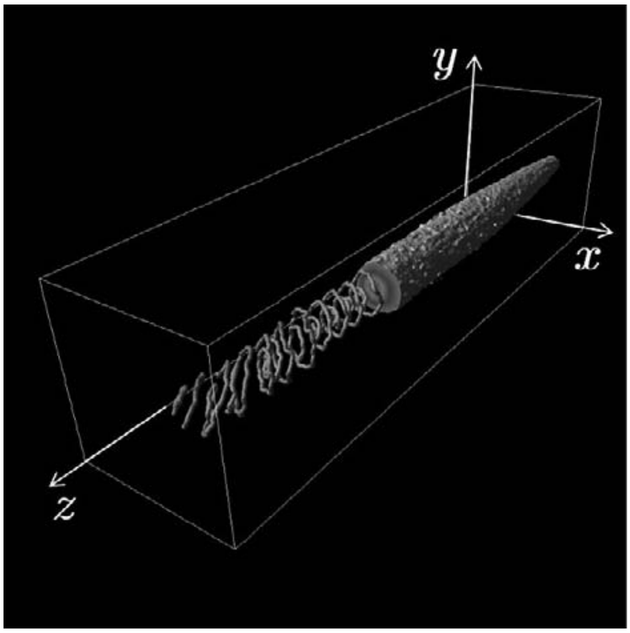

Fig. 1. Self-consistent spiral current system in a blob. Here, the system size L_x x L_y x L_z is 61.97 ρ_s x 61.97 ρ_s x 247.87 ρ_s and the initial blob size is δ_b = 3.87 ρ_s, where $\rho_s = c_s / \Omega_i$, $c_s = (T_e / m_i)^{1/2}$, and $\Omega_i = e\ B_0 / m_i$.

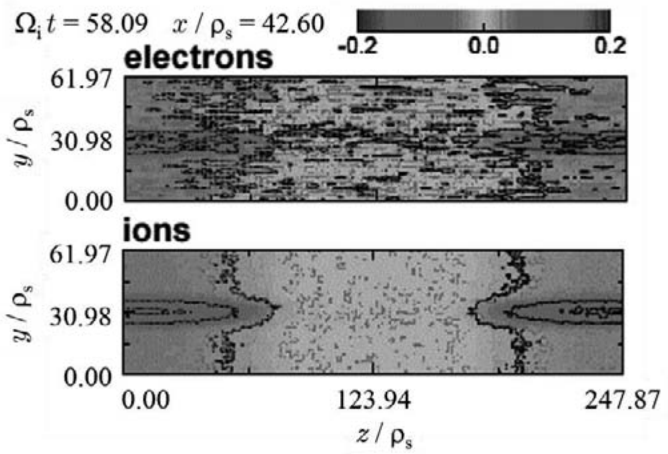

Fig. 2. Distributions of the electron and ion flows in the z direction.

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2) Krasheninnikov, S. I.: Phys. Lett. A **283** (2001) 368.
3) Krasheninnikov, S. I. et al.: J. Plasma Phys. **74** (2008) 679 and references therein.
4) Ishiguro, S. and Hasegawa, H.: J. Plasma Phys. **72** (2006) 1233.
5) Hasegawa, H. and Ishiguro, S.: Plasma Fusion Res. **7** (2012) 2401060.