§8. Spontaneous Current System in a Plasma Coherent Structure

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In recent magnetic confinement fusion device experiments, it has been observed that the density profile in the far scrape-off layer (SOL) is flatter than the exponential distribution which is expected from a diffusion model[1)]. Motivated by these experiments, some theoretical and computational studies about SOL plasmas have been made. Then a theory of plasma blob dynamics has been suggested as the mechanism of the non-diffusive (convective) radial transport[2)]. The plasma blob is a filamentary coherent structure along the magnetic field line, appears intermittently, and propagates from the edge of core plasma to the first wall. Such a structure is believed to transport a plasma into the far SOL across magnetic field lines. Many authors have studied dynamics of blobs on the basis of two-dimensional reduced fluid models[3)]. In such kind of macroscopic models, however, kinetic effects, such as sheath formation between plasma and divertor plate and velocity difference between ions and electrons, are considered under some assumptions and treated as some adjustable parameters. Thus, in this study, we investigate blob dynamics with the first principles method, that is, a three dimensional electrostatic plasma particle simulation[4, 5)].

Figure 1 shows the configuration of the particle simulation. 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 $2L_xB_0/(3L_x - x)$ 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 as the shaded planes shown in Fig. 1. The plane at $x = 0$ and others at $z = 0$ and L_z correspond to the first wall and divertor plates, respectively. In the y direction (corresponding to the poloidal direction), periodic boundary condition is applied. A blob is initially located as a column along the ambient magnetic field (as shown in Fig. 1). The initial density configuration of a blob in the cross section is given by the Gaussian distribution with the width δ_b.

In the simulations, we found the spontaneous electric current system in a blob. And then, we have analyzed this current system in this fiscal year. Figure 2 shows the streamlines of the electric current in a blob. Here, the viewing direction in Fig. 2 is about the same as that in Fig. 1, the system size $L_x \times L_y \times L_z$ is $64\lambda_{De} \times 64\lambda_{De} \times 256\lambda_{De}$, and the initial blob size is $\delta_b = 4\lambda_{De}$. Figure 2 indicates that the current system in a blob has a spiral configuration due to the diamagnetic current and the parallel flows.

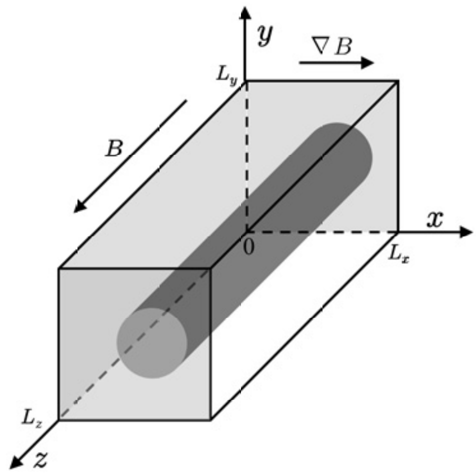

Fig. 1: Configuration of the simulation.

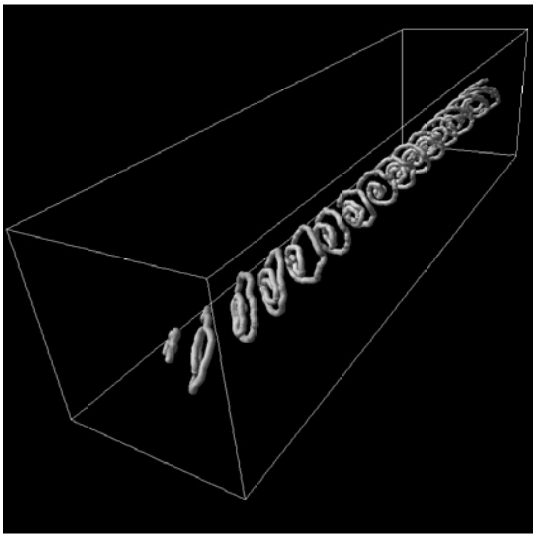

Fig. 2: Streamlines of the electric current in a blob.

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4) Ishiguro, S. and Hasegawa, H.: J. Plasma Phys. **72** (2006) 1233.

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