§2. Particle Simulation of Plasma Coherent Structures

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Recently, it is observed that filamentary coherent structures are formed intermittently and propagate from the edge of core plasma to the first wall in scrape-off layer (SOL) of magnetic confinement fusion devices[1)]. Such structures are called "blobs" and are believed to transport a plasma into the far (second) SOL across magnetic field lines. Many authors have studied dynamics of blobs on the basis of two-dimensional reduced fluid models[1)]. In such kind of macroscopic model, however, kinetic effects, such as sheath formation between plasma and divertor plate and velocity difference between ions and electrons, are treated under some assumptions and parameterization. Thus, in this study, we investigate microscopic dynamics of blobs with a three dimensional electrostatic plasma particle simulation[2)].

Figure 1 shows the configuration of the simulation. An external magnetic field is pointing into the z direction (equivalent to the toroidal direction). The strength of magnetic field increases in the positive x direction (equivalent 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 (equivalent 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. A more detailed description of parameters is shown in Ref. [3].

In the simulations, we have observed the spontaneous electric current system in a blob. In Fig. 2 we show the electron density distribution (the left panel) and the distribution of the y component of electric current density (the right panel) in the x-y plane at $z = L_z/2$ at $\omega_{pe}t = 1000$ where 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 diamagnetic current is created in the blob. Further, it is found that the positive y direction current is larger than the negative direction current. Figure 3 shows the distributions of the z component of electric current density in the z-y plane at $x = 45\lambda_{De}$ at $\omega_{pe}t = 1000$. The z-y plane in Fig. 3 intersects the center of the blob. Figure 3 indicates that the current flows from the middle to the divertors in the upper part of blob. On the other hand, the current in the lower part is in the counter direction to that in the upper part. The investigation into the effect of this current shear will be one of topics in future work.

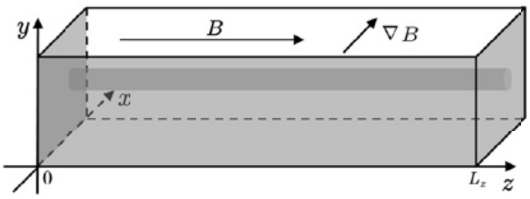

Fig. 1: Configuration of the simulation.

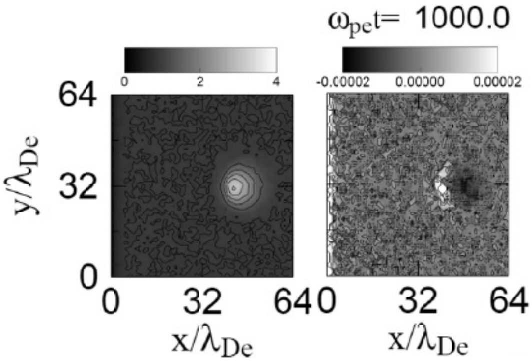

Fig. 2: Electron density distribution (the left panel) and distribution of the y component of electric current density (the right panel) in the x-y plane at $z = L_z/2$ at $\omega_{pe}t = 1000$.

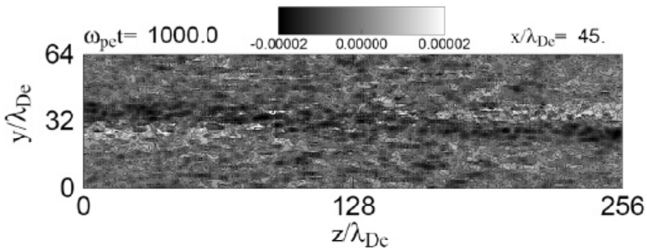

Fig. 3: Distribution of the z component of electric current density in the z-y plane at $x = 45\lambda_{De}$ at $\omega_{pe}t = 1000$.

1) Krasheninnikov, S. I. et al.: J. Plasma Phys. **74** (2008) 679 and references therein.

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

3) Hasegawa, H. and Ishiguro, S.: Plasma Fusion Res. **7** (2012) 2401060.