§1. Simulation Study of Microscopic Dynamics on Non-Diffusive Plasma Transport

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Intermittent filamentary coherent plasma structures which are called “blobs” and formed along the magnetic field line in scrape-off layer (SOL) are thought to produce non-diffusive (i.e., convective) plasma transport from the edge of core plasma to the first wall in magnetic confinement fusion devices[1]. Many theoretical and numerical studies about blob dynamics have been conducted on the basis of two-dimensional reduced fluid models[1, 2]. However, closure of parallel current and kinetic effects (e.g., sheath formation between a SOL plasma and a divertor plate, velocity difference between electrons and ions, particle motions, velocity distribution, etc.) are treated under some assumptions and parameterization in such kind of macroscopic models. Thus, we have developed a three-dimensional electrostatic plasma particle simulation code with particle absorbing boundaries[3] and investigated kinetic dynamics on the blob propagation[4, 5].

On the other hand, it has been pointed out that the propagation of “hole” structures can induce impurity transport[1, 6]. Here, the “hole” is the filamentary coherent structure where the plasma density is lower than background plasma. However, any numerical investigations about the impurity transport by the hole propagation have not been performed. Therefore, in this fiscal year, we have improved our particle simulation code to calculate hole dynamics.

In the simulations, an ambient magnetic field is pointing into the z direction (corresponding to the toroidal direction). The strength of magnetic field varies in the 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 the both ends of z axis (corresponding to the first wall and divertor plates, respectively). Periodic boundary condition is applied in the y direction (corresponding to the poloidal direction). A hole is initially located as a column along the external magnetic field. The initial density configuration of a hole in the cross section is given by the Gaussian distribution.

Figure 1 shows the time evolutions of the electric potential and electron density distributions on the poloidal cross section at $z = L_z / 2$, which have been obtained from the preliminary simulation. This figure confirm that the dipole potential structure is formed in the hole and that the hole propagates in the grad-B direction. Furthermore, observed hole propagation speeds are in agreement with the estimation from the fluid model.

In future work, we will investigate the dynamics of blob and hole propagations in the plasma with impurity ions and the impurity transport by a blob or hole structure.

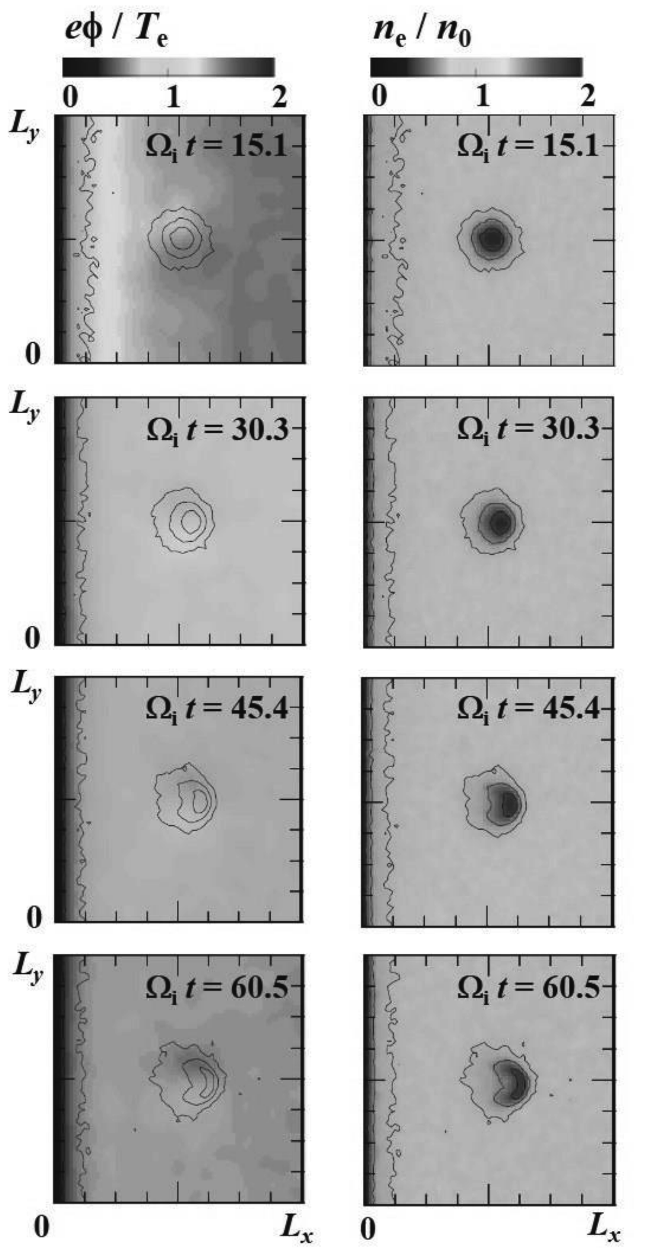

Fig. 1. Time evolutions of the electric potential distribution (left panels) and the electron density distribution (right panels).

1) Krasheninnikov, S. I. et al.: J. Plasma Phys. **74** (2008) 679 and references therein.
2) D’Ippolito, D. A. et al.: Phys. Plasmas **18** (2011) 060501 and references therein.
3) Ishiguro, S. and Hasegawa, H.: J. Plasma Phys. **72** (2006) 1233.
4) Hasegawa, H. and Ishiguro, S.: Plasma Fusion Res. **7** (2012) 2401060.
5) Hasegawa, H. and Ishiguro, S.: Phys. Plasmas **22** (2015) 102113.
6) Krasheninnikov, S. I. et al.: Proc. 19th IAEA-FEC (2003) IAEA-CN-94/TH/4-1.