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プラズマブロブにおける自発的フローと運動論的効果
Spontaneous flows and kinetic effects in a plasma blob

長谷川裕記[1, 2], 石黒静児[1, 2]
HASEGAWA Hiroki[1, 2] and ISHIGURO Seiji[1, 2]

核融合研[1], 総研大[2]
NIFS[1], Sokendai[2]

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 authors have studied the plasma transport in SOL theoretically. 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 lines, appears intermittently, and propagates from the edge of core plasma to the first wall. Such structures are thought to play an important role in plasma particles and heat flux transports into the far SOL across magnetic field lines. Many theoretical and computational studies about dynamics of blobs on the basis of two-dimensional reduced fluid models have been made [3, 4]. In such kind of macroscopic fluid models, however, kinetic effects (such as sheath formation between plasma and divertor plates, velocity difference between ions and electrons, temporal and spatial variations of particle velocity distributions, and so on) are treated under some assumptions and parameterization.

Thus, in this study, we have investigated microscopic dynamics in a blob by means of a three-dimensional electrostatic plasma particle simulation code with particle absorbing boundaries [5, 6]. In the particle simulation, an external magnetic field B 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), i.e., $\partial B / \partial x > 0$. The particle absorbing boundaries are placed on the both ends in the z direction (corresponding to end plates (divertor plates)) and the end at $x = 0$ (corresponding to a first wall). A coherent structure is initially set as a column along the external magnetic field and propagates to the first wall. First, we have investigated the configurations of spontaneous particle flows in a plasma coherent structure. As shown in Fig. 1, we have found that a spiral current system is formed in a plasma blob and characteristic features in the velocity distributions of plasma particles in a blob have been observed. Furthermore, when the magnetic field strength is decreased, we have found that the symmetry breaking in a blob profile occurs (see Fig. 2). This fact is thought to indicate that the effect of gyro motion of plasma particles induces the symmetry breaking.

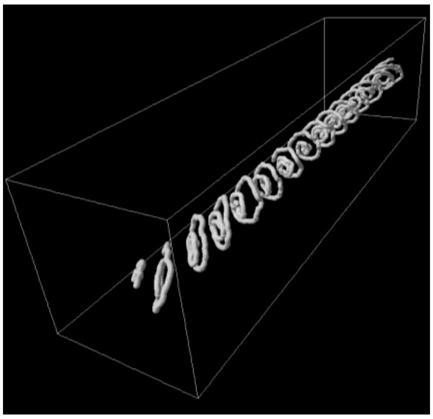

Fig. 1 Streamlines of the electric current in a blob.

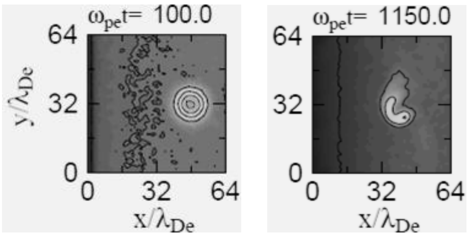

Fig. 2 Electron density distributions in the x-y plane at $z = L_z/2$ at $\omega_{pe}\, t$ = 100 and 1150 where the magnetic strength is set as $|\Omega_e| / \omega_{pe} = 1$.

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