

## §26. Kinetic Dynamics of Plasma Blob Propagation

Ishiguro, S., Hasegawa, H.

In recent experiments, it has been observed that the density in the far scrape-off layer (SOL) in magnetic confinement fusion devices is higher than the estimation calculated from a diffusion model<sup>1)</sup>. Motivated by such observations, some authors have investigated the SOL plasma theoretically. Then a theory of plasma blob dynamics has been proposed as the mechanism of the non-diffusive (that is, convective) radial plasma transport<sup>2)</sup>. The plasma blob is an intermittent filamentary coherent structure along the magnetic field line and moves from the edge of core plasma to the first wall by the  $E \times B$  drift since the electric field is induced in a blob by the charge separation caused by the  $\text{grad-}B$  or curvature drifts. Many pieces of evidence which shows that such structures are produced in peripheral plasmas have been reported<sup>3)</sup>. Further, many authors have studied blob dynamics on the basis of two-dimensional reduced fluid models<sup>3)</sup>. 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 adjustable empirical parameters. Thus, in this study, we investigate kinetic dynamics of blobs with a three dimensional electrostatic plasma particle simulation<sup>4,5)</sup>.

The configuration of particle simulation is as follows. 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  $x = 0$ . The plane at  $x = 0$  corresponds to the first wall. In the  $y$  (corresponding to the poloidal direction) and  $z$  directions, periodic boundary condition is applied. A blob is initially set as a column along the external magnetic field. The initial density profile of the blob in the cross section is given by the Gaussian distribution with the width  $\delta_b$ . The system size  $L_x \times L_y \times L_z$  is  $61.97 \rho_s \times 61.97 \rho_s \times 15.49 \rho_s$ . The initial radius of the blob is  $\delta_b = 3.87 \rho_s$ . Here,  $\rho_s = c_s / \Omega_i$  where  $c_s$  is the ion acoustic speed given as  $c_s = (T_e / m_i)^{1/2}$  and  $\Omega_i = e B_0 / m_i$ .

In the last fiscal year, we found the symmetry breaking in blob propagation when the ion temperature is higher (See Fig. 1). In this fiscal year, we have studied its effect on plasma transport and the mechanism of the symmetry breaking. Figure 2 shows the time variation of the  $x$  position of the maximum electron density in a blob. Figure 2 indicates that the radial velocity for larger  $T_i / T_e$  blob becomes small after the blob moves for  $10 \sim 20 \rho_s$ . Furthermore, we have found the unbalanced dipole potential

structure in larger  $T_i / T_e$  blobs. Such a potential structure arises from the Larmor motion of ion particles and causes the symmetry breaking in blob propagation.

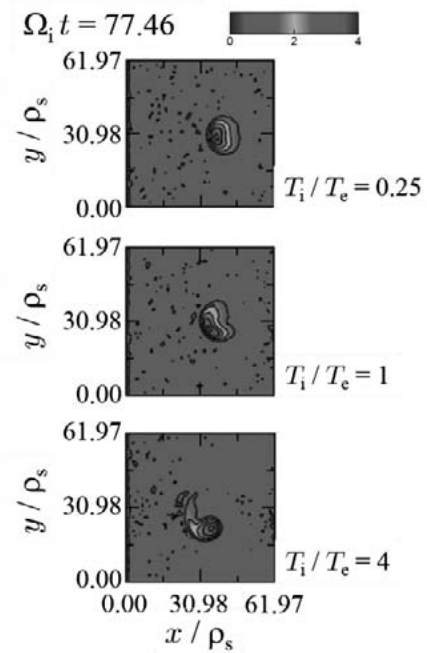


Fig. 1. Electron density distributions in the  $x$ - $y$  plane at  $z = L_z / 2$  at  $\Omega_i t = 77.46$  where the ion-to-electron temperature ratio is set as  $T_i / T_e = 0.25, 1,$  and  $4$  in the upper, middle, and bottom panels, respectively.

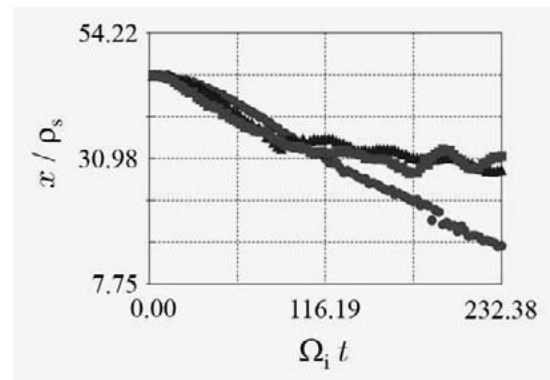


Fig. 2. Time variation of the  $x$  position of the maximum electron density in a blob. The circle, triangle, and square represent the observations for  $T_i / T_e = 0.25, 1,$  and  $4$ , respectively.

- 1) Umansky, M. V. et al.: Phys. Plasmas **5** (1998) 3373.
- 2) Krasheninnikov, S. I.: Phys. Lett. A **283** (2001) 368.
- 3) D'Ippolito, D. A. et al.: Phys. Plasmas **18** (2011) 060501 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.