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Effects of End Plates and Kinetic Dynamics on Filamentary Plasma Structure Formations

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Recently, the intermittent filamentary plasma structures called “blob” have been investigated experimentally, theoretically, and numerically by many authors since such structures are thought to play a significant role in a radial non-diffusive plasma transport in boundary layers of various magnetic confinement fusion devices. In most of the theoretical and numerical studies, the filament formation mechanism and propagation dynamics have been considered on the basis of two-dimensional reduced fluid models [1, 2]. On the other hand, we have performed simulations of filament propagations with the three-dimensional (3D) electrostatic particle-in-cell (PIC) simulation code called “p3bd” [3-5] in order to study microscopic properties on the propagation. Using the 3D-PIC simulation, we showed a self-consistent current system in a filament [6], a temperature structure in a filament [6], and an ion temperature effect on the filament dynamics [7, 8]. Also, interactions between a filament and impurity ions have been investigated [9, 10].

However, in these previous works, we simulated only the propagation dynamics of a filament structure which is initially given in a simulation system. That is, a filament formation mechanism has been beyond the scope of our previous works. In order to study the formation mechanism with the 3D-PIC simulation, we need to carry out large-scale simulations. Therefore, we have developed the upgraded-p3bd (up3bd) code in which the one or two dimensional domain decomposition is applied [11, 12]. In the simulation with the up3bd code in which only a plasma density gradient perpendicular to the magnetic field is initially given in the system representing boundary layer configuration, we have observed the non-diffusive plasma transport induced by instability. In the early stage, the growth of density perturbation with the short-wavelengths in the direction parallel to the magnetic field is observed, while that with the long-wavelengths is found in the next stage [13].

In this study, we have studied effects of end plates on the non-diffusive plasma transport. Figure 1 shows the time variations of electron radial fluxes for the cases with / without end plates. Here, in the case without end plates, the periodic boundary condition is applied in the direction parallel to the magnetic field. This figure indicates that the flux without end plates becomes larger than that with end plates after $\Omega_i\, t \sim 160$. This fact is thought to arise from the significant growth of long-wavelength perturbation in the case without end plates. Also, effects of ion heating with an induced wave will be discussed in the presentation.

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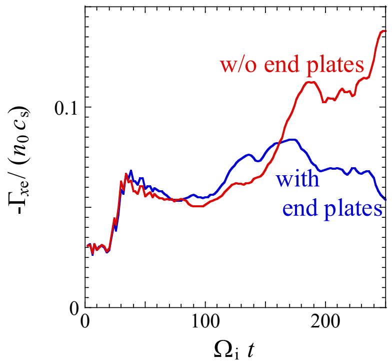

Figure 1. Time variations of averaged electron radial fluxes for the cases with / without end plates at the density transition region, $x = L_x / 2$. Here, $-x$ is the radial direction, the initial plasma density is given by n_0 { tanh [(x - L_x / 2) / Δ] + 1 }, Δ is the transition width, and the magnetic field strength is set as $B = 2\, L_x\, B_0 / (3\, L_x - x)$.

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