§24. Three-Dimensional Particle-in-Cell Simulation of Blob Transport

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Recently it is recognized that plasma is transported across magnetic field lines as long-lived macroscopic coherent structures “blobs” in scrape-off layer (SOL) of magnetic confinement fusion devices[1-5]. In order to reveal detail microscopic physics related to blob dynamics, we have developed three dimensional particle-in-cell (PIC) code with particle absorbing boundaries[6].

Configuration of our three dimensional PIC simulation is following. External magnetic field is pointing into the z-direction. Particle absorbing boundaries corresponding to diverter plates are placed in the both ends of z-axis. A particle absorbing plate corresponding to the first wall is also placed at the one end of the x-axis. Particle reflecting plane is placed in the other end of the x-axis. A particle impinging to the absorbing boundaries is removed from the system. In the y-direction, periodic boundary condition is applied.

Employed simulation parameters are followings: The system size L_x X L_y X L_z is 256 X 128 X 2048 and 256 X 128 X 2048 spatial grid system is used. The ion to electron mass ratio m_i/m_e is fixed at 100 and the ion to electron temperature ratio T_i/T_e is 0.25. External magnetic field along the z axis has a gradient in the negative x-direction. The ratio of the ion cyclotron frequency defined at x=256 to the electron plasma frequency defined by averaged plasma density is 0.025. The space and time are normalized by averaged Debye length and averaged plasma frequency, respectively. The normalize time step width is 0.01. Initially, high density region with spaghetti-like shape is set around x=192 and y = 64.

Ions and electrons drift in the positive y-direction and negative y-direction due to grad-B drift, respectively. Thus, top side and bottom side of the high-density region are positively and negatively charged, respectively. As a result, an electric field in the negative y-direction in the high-density region is created. The high density region moves in the negative x-direction due to EXB drift.

Figure 1 shows the time evolution of ion density profile in the x-y plane at z=1024. This indicates that the high density region moves in the negative x-direction. Although the shape is slightly modified, the collapse does not occur. The propagating speed is about 0.1 c_s, where c_s is the ion acoustic speed. Small scale structures are also observed in the high-density region.

Longer time behavior and detailed physics will be investigated in near future. The code has been updated for more efficient simulations.

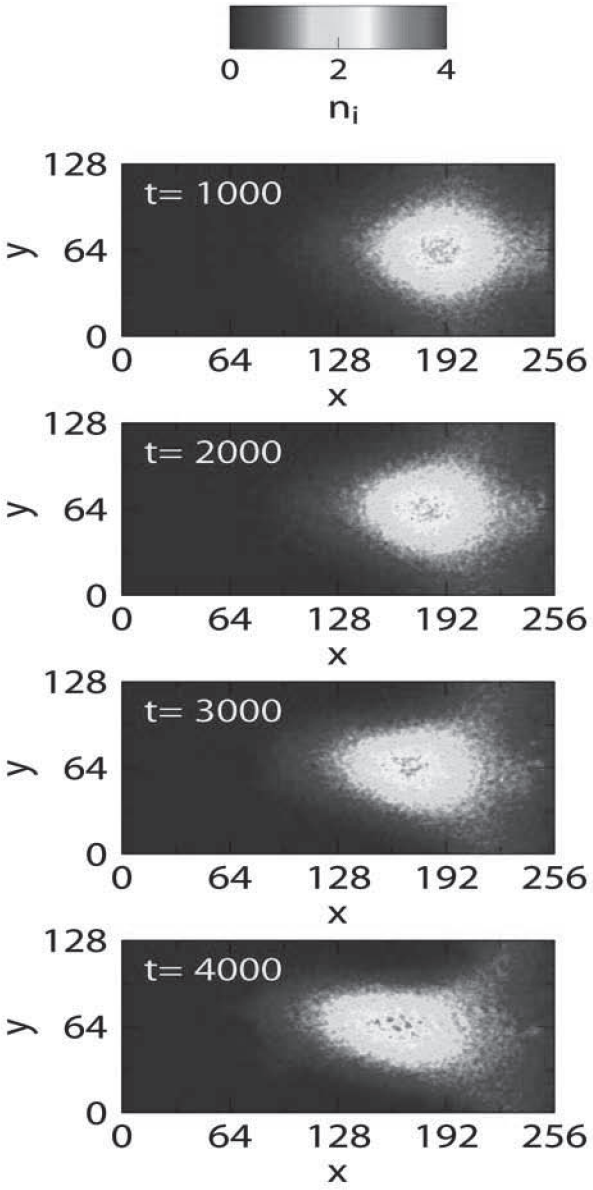

Fig. 1. Time evolution of ion density profile in the x-y plane at z=1024. The high-density region moves in the negative x-direction due to EXB drift.

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