§25. Three Dimensional Particle-in-Cell Simulation of Blob Dynamics

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It is recognized that a 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]. Many numerical works based on two-dimensional reduced models have been performed and instability and modification of blobs have been discussed. [6,7] In this kind of macroscopic model, kinetic effects, such as sheath formation between plasma and wall, are treated under some assumptions and parameterization. However, the verification of the assumptions cannot be done in this framework. In addition, direct comparison between these numerical models and experiments have not been performed because of difficulty of detailed measurements in large scale experiments. It is possible that a full three dimensional kinetic simulation can play an important role to reveal microscopic features in blob dynamics.

As a first step, we have developed a three dimensional particle-in-cell (PIC) simulation code with particle absorbing boundaries[8] in order to investigate real three dimensional kinetic feature of blob dynamics. The framework of PIC simulation, it is not necessary to make any assumptions in potential formation such as sheath formation and electric field caused by grad-B drift.

Configuration of our three dimensional PIC simulation is followings. An external magnetic field is pointing into the z-direction. The strength of magnetic field decreases in the positive x-direction. This gradients causes grad-B drifts of charged particles. 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.

Figure 1 shows the feature of high density blob (rod) which is initially located as a column in the system. The blob is modified to cigar like structure in time because plasma particles are absorbed by the particle absorbing plane. At the same time the body moves across the magnetic field lines. This motion is explained as follows. 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[5]. Potential structure created particle drifts are explicitly confirmed by the direct measurement in the simulation.

Comparison between our real three dimensional kinetic simulation and numerical result based on macroscopic model equation and detailed kinetic behaviors based on velocity space instabilities are under consideration.

The code has been developed for the previous plasma simulator, i.e. vector parallel super computer, by using High Performance Fortran (HPF). New plasma simulator, which is installed March 2009, is scalar parallel computer and does not support HPF. We have rewrite simulation code for scalar computer by using Message Passing Interface (MPI). Unfortunately we do not have good performance at the new plasma simulator, because the structure of the code is not conformable with the new plasma simulator. The improvement of the code is also under consideration.

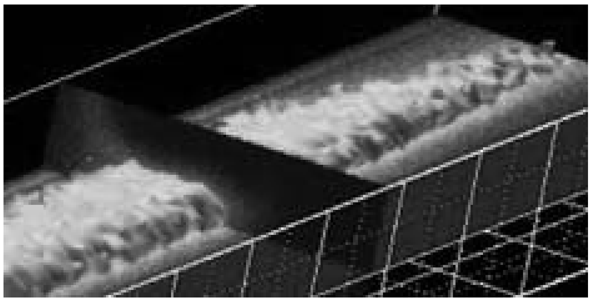

Fig. 1 Isosurface and contour plot of ion density.

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