Edge Plasma Modeling Using PARASOL Code

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In magnetic confinement systems, not only open systems like a mirror but also closed systems like a tokamak, there exist the regions of open-field plasmas. An open-field plasma surrounding a closed-field plasma is called a scrape-off-layer (SOL) plasma or a divertor plasma. Since the open-field plasma attaches walls of a device directly, plasma particles and heat escape to the walls mainly along magnetic field lines. Utilizing this nature, we expect divertor functions for the heat removal, ash exhaust, and impurity shielding in fusion reactors, such as ITER. Analyses of experiments on the above functions in present devices and predictions of their performances in future reactors have been carried out by using comprehensive simulation codes with the fluid model. In the fluid model for SOL/divertor plasmas, however, various physics models are introduced, i.e., boundary conditions at the plasma-wall boundary, heat conductivity, viscosity and so on. Kinetic approach is required to examine the validity of such physics models. One of the most powerful kinetic models is the particle simulation. The particle simulation, in which particle motions and the electrostatic potential are computed self-consistently, can describe accurately the sheath formation.

We have been developing a particle simulation code PARASOL (PARticle Advanced simulation for SOL and divertor plasmas), and studying the edge modeling. This code treats various kind of situations; one-dimensional (1D) steady state, 1D dynamic state (such as ELM behavior), slab 2D configuration, and 2D configuration with separatrix like a tokamak divertor configuration. The magnetic field is given. The electrostatic field inside a system is calculated self-consistently with a usual PIC method. Coulomb collisions play very important role in open-field plasmas. For instance, the collisional diffusion in the velocity space is the main mechanism to supply high-energy electrons. These electrons can escape to the divertor plate, while low energy electrons are trapped in a SOL plasma by the sheath potential. The collisional effect is simulated by a binary collision model.