Multi-Hierarchy Simulation Model for Magnetic Reconnection Studies
- Dynamical Conversion of Algorithm -

Shunsuke Usami[1], Hiroaki Ohtani[1,2], Ritoku Horiuchi[1,2] and Mitsue Den[3]

[1]*National Institute for Fusion Science, Toki 509-5292, Japan*
[2]*The Graduate University for Advanced Studies (SOKENDAI), Toki 509-5292, Japan*
[3] *National Institute of Information and Communications Technology, Tokyo, Koganei, 184-8795, Japan*

Collisionless magnetic reconnection is one of the fundamental processes in which magnetic field energy is converted to kinetic energy. It plays an essential role in the rapid energy release in laboratory fusion device and astrophysical plasmas. Furthermore, magnetic reconnection attracts considerable attention as a typical multi-scale phenomenon. When magnetic reconnection takes place, the global change in field topology and large plasma transport occur, while electrical resistivity controlled by microscopic process is necessary in the vicinity of reconnection points. In order to understand its multi-hierarchy structure completely, we develop a multi-hierarchy simulation model, which deals with both microscopic and macroscopic physics consistently and simultaneously.

Our multi-hierarchy model is based on the domain decomposition method, in which the domains differ in algorithm [1, 2]. Physics in the domain where some microscopic dissipation mechanisms are required is solved by PIC algorithm (PIC domain). On the other hand, dynamics outside the PIC domain is expressed by MHD algorithm (MHD domain), in which the ideal MHD equation is used as the basic equation, since electrical resistivity is assumed to be generated by kinetic process only in the PIC domain. Between the PIC and MHD domains, an interface domain with a finite width is inserted in order to interlock two domains smoothly.

In 2009, we have achieved the simulation of collisionless driven reconnection with the multi-hierarchy model, namely plasma inflows come from the MHD domain and drive magnetic reconnection in the PIC domain [3]. It was confirmed that reconnection process found in the multi-hierarchy model is true physics.

In nature, however reconnection points move with time dynamically and then region which need to be expressed by kinetic algorithm also move. Therefore we have been developing a method that system automatically detects kinetic region and converts calculation algorithm as simulation is running. As the first step of dynamical conversion method of algorithm, we perform the following simulation. Initially, whole domain is taken to be the MHD domain. When the certain time passes, a part of MHD domain is converted to the PIC domain, namely the MHD simulation is switched to the multi-hierarchy simulation based on the domain decomposition method. In presentation, we would like to show the first result of the above simulations.

[1] S. Usami, H. Ohtani, R. Horiuchi, and M. Den, Commun. Comput. Phys. **4**, 537 (2008).
[2] S. Usami, H. Ohtani, R. Horiuchi, and M. Den, Commun. Comput. Phys. in press.
[3] S. Usami, H. Ohtani, R. Horiuchi, and M. Den, Plasma Fusion Res. **4**, 049 (2009).