03pB04

磁気リコネクション研究のための多階層シミュレーションモデルの開発
Development of Multi-Hierarchy Simulation Model for Magnetic Reconnection Study

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We believe that a multi-hierarchy simulation is very useful and indispensable tool to investigate the entire picture of magnetic reconnection. It is because magnetic reconnection is complex phenomenon controlled by multiple spatiotemporal scale physics. When magnetic reconnection takes place, field topology is globally changed and large-scale transport occurs. On the other hand, some kinetic processes in the vicinity of reconnection points are needed as trigger.

Then, we have developed a multi-hierarchy model which solves macroscopic and microscopic physics simultaneously and self-consistently. In our model, the domain decomposition method is employed. In other words, different algorithms are used in different domains. The MHD domain deals with macroscopic dynamics, and the PIC domain solves microscopic physics, respectively. With the hierarchy-interlocking model in the upstream direction, we have successfully demonstrated multi-hierarchy simulations of collisionless driven reconnection [1, 2].

Now we have extended our multi-hierarchy model to ones with the following two schemes for aiming to apply it to a larger system of magnetic reconnection. One is extension to the two-dimensional hierarchy-interlocking model as shown in Fig. 1 (model A). The other is inserting the PIC domain with Coulomb collision effects (collisional PIC domain) between the PIC and the MHD (interface) domains as displayed in Fig. 2 (model B). In both models, we are examining it physical reliability.

First let us introduce the model A. We perform a multi-hierarchy simulation in which plasmas are injected inward from the surrounding MHD domain. It is observed that plasmas are smoothly and continuously flow from MHD to PIC domains through the interface domains, and pile up in the PIC domain.

Next we explain the model B. The algorithm of Coulomb collision is based on the so-called Takizuka model [3]. This model B contributes to hierarchy-interlocking in the downstream direction of magnetic reconnection. Plasmas propagate in the opposite direction of the model A, namely plasmas are ejected from PIC to MHD domains via collisional PIC and interface domains. We can see that plasma flow with non-Maxwellian velocity distribution relaxes to Maxwellian distribution and consequently plasmas propagate with low unphysical noises from PIC to MHD domains.

In our presentation, we would like to show some simulation results by the multi-hierarchy models described above, and talk about the future plan.

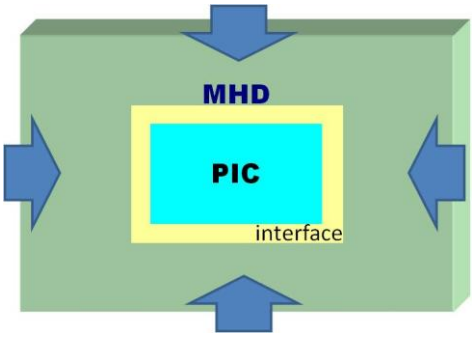

Fig. 1: Schematic diagram of the two-dimensional hierarchy-interlocking model.

Fig. 2: Schematic diagram of the PIC - collisional PIC - MHD interlocking model, which mimics the downstream direction.

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