Magnetic Reconnection Controlled by Multi-Hierarchy Physics in an Open System

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Magnetic reconnection is a typical cross-hierarchy phenomenon controlled by multi-scale physics from microscopic physics relating to electron and ion dynamics through macroscopic one such as plasma transport in a global scale. In order to investigate full picture of magnetic reconnection, we have developed two kinds of numerical simulation models. One is the electromagnetic particle model for an open system (“PASMO”). The other is multi-hierarchy simulation model for magnetic reconnection (“MARIS”).

A series of particle simulations using PASMO code have revealed new features of microscopic physics of collisionless driven reconnection in open systems. The growth of pressure tensor and formation of non-Maxwellian distribution function in the central current layer demonstrate that the meandering orbit effect play a crucial role in triggering collisionless reconnection [1,2].

Anomalous resistivity due to plasma instabilities excited in an ion-scale current sheet is also investigated as another triggering mechanism of collisionless reconnection. Lower hybrid drift instability (LHDI) is excited in the periphery of the current sheet in a relatively early phase. Anisotropic ion distribution is formed through an interaction between electrostatic fluctuation excited by LHDI and meandering ions with large orbit amplitude and causes the growth of a longer kink mode in the central region [3]. The generated anomalous resistivity is large enough to explain magnetic reconnection phenomena observed in the magnetosphere and laboratory experiments.

The multi-hierarchy simulation model consists of three parts, i.e., MHD model to describe global dynamics of reconnection phenomena, PIC model to describe the microscopic processes in the vicinity of reconnection point where PASMO code is used, and interface model to describe the interaction between micro and macro hierarchies [4,5]. The model is applied to a few numerical test programs and collisionless driven reconnection in a simple geometry and is confirmed to work well. We will describe the details of simulation model and obtained new features of collisionless driven reconnection in our presentation.

[1] A. Ishizawa and R. Horiuchi, Phys. Rev. Let., Vol.95 (2005) 045003.
[2] R. Horiuchi and H. Ohtani, Comm. Comp. Phys., Vol. 4 (2008) 496.
[3] T. Moritaka R. Horiuchi, Phys. Plasmas, 15, 092114(2008).
[4] R. Horiuchi, H. Ohtani, and A. Ishizawa, J. Plasma Phys., Vol. 72, (2006) 953.
[5] S.Usami, H. Ohtani, R. Horiuchi, and M. Den, Comm. Comp. Phys., Vol. 4 (2008) 537.