Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

PEM26-01 会場:102B 時間:5 月 22 日 13:45-14:00

３次元磁気リコネクションにおけるプラズモイド誘導乱流
Plasmoid-induced turbulence in 3D magnetic reconnection

藤本 桂三 [1*], Richard Sydora[2]
FUJIMOTO, Keizo[1*], SYDORA, Richard[2]

[1] 独立行政法人理化学研究所, [2] アルバータ大学
[1]RIKEN, [2]University of Alberta

One of the main issues on magnetic reconnection processes is the mechanism breaking the frozen-in condition around the x-line and providing the electric resistivity in collisionless plasmas. It has been recognized empirically in magnetohydrodynamic simulations that the Petschek-type fast reconnection can be achieved only when an intense resistivity arises locally near the x-line. However, the generation mechanism of the resistive effects in collisionless plasmas is poorly understood in the kinetic framework. In 2D reconnection, it has been demonstrated by kinetic simulations that the momentum transport due to the Speiser-type motion of the electrons around the x-line gives rise to the so-called inertia resisticity which results in the electron viscosity term in the generalized Ohm's law. Although the electron inertia resistivity gives intense dissipation under the thin current layer on the order of the electron inertia length, such a thin current sheet has been observed neither in the laboratory experiments nor in the geomagnetosphere. The observational results have shown that the current sheet width during the fast reconnection is much larger than that in the 2D kinetic simulations and electromagnetic wave activities are usually accompanied. These characteristics infer the existence of the anomalous effects due to wave-particle interactions that are not incorporated in the 2D simulations.

In order to investigate the 3D effects in the dissipation process, the present study has performed large-scale particle-in-cell (PIC) simulations in 3D system. The code employs the adaptive mesh refinement (AMR) and is massively parallelized, which enables us to perform highly efficient simulations on state-of-the-art supercomputers. The 3D simulations revealed that the thin current layer is unstable to a low-frequency electromagnetic mode with $w_{ci} < w < w_{LH}$, where w_{ci} and w_{LH} are the ion cyclotron frequency and the lower hybrid frequency, respectively. The mode propagates in the cross-field direction and produces the turbulent flow around the electron current layer, so that the electron current is impeded by the turbulence on average. The turbulence effect is evaluated by the anomalous terms in the generalized Ohm's law and is found to provide significant contribution to the force balance. In particular, it is very interesting to remark that the turbulence effect is strongly enhanced in association with the plasmoid ejections. Although the present simulations have been carried out for an unrealistic ion-to-electron mass ratio (mi/me = 100), the linear analyses have demonstrated that the mode still survives for the real mass ratio (mi/me = 1836).

In this paper, we show the recent kinetic simulation results in large-scale 3D system, where it is described that the intense turbulence is caused due to the plasmoid ejections. The possible scenario under the real mass ratio will be discussed using the linear analyses based on the two-fluid equations.
Keywords: 3D magnetic reconnection, dissipation mechanism, turbulence, plasmoid, AMR-PIC simulation