Impact of diffusion processes on magnetic reconnection

*Takashi Minoshima[1], Takahiro Miyoshi[2], Shinsuke Imada[3]

1.Department of Mathematical Science and Advanced Technology, Japan Agency for Marine-Earth Science and Technology, 2.Graduate School of Science, Hiroshima University,, 3.Institute for Space-Earth Environmental Research, Nagoya University

Magnetic reconnection intrinsically contains a hierarchical structure ranging from the fully kinetic scale to the magnetohydrodynamic (MHD) scale. In order to identify the essential physics necessary to model the reconnection, numerical simulations have been conducted with a variety of codes from kinetic codes to conventional resistive MHD codes (Birn et al. 2001). They have shown that only the MHD simulation with uniform resistivity fails to trigger fast reconnection, indicating that resistive MHD would be insufficient to model it.
The role of resistive dissipation on the reconnection has been extensively investigated in the framework of MHD. Recent theoretical and numerical studies have proposed a dynamic model dominated by plasmoids for sufficiently small resistivity beyond a classical static model. The resulting reconnection rate seems to be independent of the resistivity that may account for actual phenomena, although it does not necessarily settle the difference from the kinetic model. Meanwhile, the impact of other dissipation processes should be discussed. This study especially focuses on viscosity and heat transfer.
Viscosity controls the dissipation scale of vortex. Resistive MHD assumes it to be zero, meaning that the vortex dissipation scale is negligible small compared with the current dissipation scale. However, the ratio of the scale of vortex to current can be much larger than unity in actual environments, and it affects the dynamics. Finite heat transfer is frequently observed in association with the reconnection. It can also affect the dynamics through increasing compressibility.
In order to investigate the effect of viscosity and heat transfer on the nonlinear evolution of the reconnection, we conduct two-dimensional fully-compressible visco-resistive MHD simulations coupled with thermal conduction. We discuss that viscosity and thermal conduction considerably modify the dynamics from a resistive model. Large viscosity excites a broad vortex that enables the efficient transfer of upstream magnetic field to the reconnection region. The resulting reconnection rate increases with viscosity provided that thermal conduction is fast enough to take away the viscous heating energy. This is indicative of the importance of viscosity and heat transfer to model the reconnection against the conventional resistive MHD. We also investigate the dependence on resistivity to determine key parameters (specifically, Reynolds numbers and Prandtl numbers) governing the visco-resistive reconnection coupled with thermal conduction. Comparison with the kinetic model will be discussed.

Keywords: Magnetic reconnection, MHD simulation, Diffusion