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Effects of turbulence in fast magnetic reconnection

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Since a magnetic Reynolds number R_m is very large in space, turbulence can be observed in many situations, e.g., in the solar wind and the Earth's magnetosphere. And turbulence is considered to play important roles in various situations such as magnetic reconnection and the diffusive acceleration in shocks. Here, we focus on the relationship between turbulence and magnetic reconnection.

The research on magnetic reconnection itself started around 1960, and it has attracted much attention because of the unique phenomenon that efficiently converts magnetic field energy to kinetic and thermal energy of plasmas. It is well known that the reconnection rate depends on a magnetic Reynolds number (propotional to ${R_m}^{-1/2}$) from a representative theory for reconnection [Sweet, 1958; Parker, 1957]. However, a major problem has been that their model can not explain the fast reconnection observed in space where the magnetic Reynolds number is sufficiently large. Recently, turbulence has been paid much attention as one of agents to solve this problem. For example, it is shown by large scale numerical simulations that a reconnection rate becomes independent of magnetic Reynolds number, R_m, as R_m increases, if turbulence exists [Loureiro+, 2009]. Another study addressed an importance of self-generation of turbulence in magnetic reconnection from the viewpoint of the theory of turbulence [Yokoi and Hoshino, 2011]. This theory predicts that the cross helicity (which is defined as a macroscopic value for turbulence) generated by the breaking of symmetry in magnetic reconnection would enhance the reconnection rate dramatically.

We have developed a new simulation code based on the MHD turbulence model [e.g., Yoshizawa, 1990] in order to clarify the relationship between turbulence and magnetic reconnection. In our simulation code, equations of time evolution for the cross helicity and turbulent kinetic energy are solved in addition to the ordinal MHD equations. Then, these quantities for turbulence interact with mean quantities, like the magnetic field and the velocity, through the turbulence electromotive term in the Ohm's law. Simulation results show the generation of the cross helicity along the reconnection exhaust as the theoretical prediction. It has also turned out the effective turbulent diffusion were localized around the reconnection point due to the spatial inhomogeneity of the cross helicity, and this results in a fast magnetic reconnection. In this presentation, from the result of our simulation, we present an overview of MHD turbulence model and discuss the importance of transport and localization of turbulence in the fast magnetic reconnection.

Keywords: magnetic reconnection, turbulence, cross-helicity, laminar flow, reconnection rate, simulation