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Simulation study of magnetic reconnection in high Raynols number plasma

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Magnetic reconnection is important process for dynamics in space and laboratory plasmas. Magnetic reconnection is basically dominated by magnetic diffusion at thin current sheet as proposed by Sweet (1958) and Parker (1963). According to their theory, the reconnection rate must be inversely proportional to the square root of the magnetic Reynolds number (S). But in spite of high magnetic Reynolds number (>10^12) in magnetosphere or the solar corona, fast reconnection which rate is about 10^-2 is observed. Slow shock, the Hall- effect and some other processes are considered as the cause of accelerating reconnection. But the mechanism is not fully understood yet. Although in the Sweet and Parker theory, the stability of current sheet is assumed. The recent studies pointed out that current sheet can be destabilized when the magnetic Reynolds number is very large.

Lapenta (2008) investigated how the stability of current sheet and the reconnection rate depend on S using the numerical simulations. As a result, they suggested that, once the instability of current sheet grows, fast reconnection is realized and the reconnection rate becomes insensitive to the magnetic Reynolds number. However they studied the cases only for S = 10^3 to and 10^4 and in which relatively large disturbance of magnetic field is initially imposed to drive the instability of current sheet. Therefore, the transition from the Sweet-Parker type reconnection to the current sheet instability is not yet well understood.

In this paper, we developed the high-resolution magnetohydrodynamics (MHD) simulation of magnetic reconnection in high-S regime aiming at revealing the acceleration mechanism of magnetic reconnection . To obtain this purpose, we apply the HLLD Rieaman solver which was developed by Miyoshi and Kusano (2005) to the high resolution two-dimensional MHD simulation of current sheet dynamics. The HLLD Rieaman solver is a highly accurate and efficient scheme and recently adopted by many standard MHD packages.

In our model, the initial state is given by the Harris sheet equilibrium plus perturbation, of which the amplitude is varied as a parameter. We will talk about the dependency of magnetic reconnection rate, which is defined as the production rate of reconnected magnetic flux, both on S and the amplitude of initial perturbation. We also discuss how the size distribution of plasmoids generated by the current sheet instability is related to the acceleration of magnetic reconnection.