Current sheet thinning in high Lundquist number plasmas

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A large portion of free energy in space plasmas with high Ludquist numbers is stored in current sheets which are formed by macroscopic scale motions of the plasmas. It is considered that many explosive phenomena in the plasmas are produced by abrupt disruptions of those current sheets, i.e., magnetic reconnection. Although resistive instabilities in high Lundquist number plasmas grow slowly in general, recent theoretical and simulation studies indicate that microscopic plasma effects such as the Hall effect can promote fast magnetic reconnection in kinetic (microscopic) scale current sheets. However, there is a vast scale gap between the macroscopic and microscopic structures and dynamics, and it is unclear how the microscopic structures can be formed in the macroscopic current sheet. The aim of this study is to clarify thinning processes of the current sheet in high Ludquist number plasmas. Particularly, in this paper, the nonlinear evolution of the resistive tearing instability for high Lundquist number is investigated using very high resolution MHD simulations.

At an initial stage, the current sheet width and thickness decrease in time as expected by the linear theory until reaching the Rutherford regime. The sheet width is saturated and increases slightly at a nonlinear stage though the sheet thickness continues to decrease. After the aspect ratio of the current sheet becomes more than 100, a secondary instability occurs as pointed out by Biskamp [1986] and Loureiro, et al. [2007]. Once a secondary magnetic island, i.e., plasmoid, is created and ejected out of the sheet, the current sheet shrinks and the aspect ratio becomes far less than 100. After a short time period, the current sheet is elongated more than the criterion of the secondary instability again. The simulation results indicate that these processes can be repeated intermittently in space and time, producing microscopic structures. The detailed structures and dynamics of the current sheet will be discussed at the meeting.

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