Computational & Information Systems Laboratory

NCAR

Joint HAO GTP Seminar

Onset of Fast Reconnection in High-Lundquist-Number Plasmas Mediated by the Plasmoid Instability

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The problem of fast magnetic reconnection in high-Lundquist-number (S) plasmas has been an active area of research for several decades. The main challenge is to explain why reconnection in nature or laboratory devices (including fusion devices) can proceed rapidly from a relatively quiescent state in a weakly collisional plasma characterized by high values of the Lundquist number (S). The classical Sweet-Parker theory, based on resistive MHD, predicts a reconnection rate that scales as $S^{-1/2}$. For many systems of interest, the Sweet-Parker reconnection rates are much slower than those observed. Recent work has demonstrated that there is a fundamental flaw in the Sweet-Parker argument, even within the framework of resistive MHD. When the Lundquist number exceeds a critical value, the Sweet-Parker layer is unstable to a super-Alfvenic tearing instability, hereafter referred to as the plasmoid instability, with a growth rate that *increases* with increasing S. Thus, the original Sweet-Parker current sheet breaks down into a chain of plasmoids and progressively thinner current sheets. Numerical simulations, supported by heuristic scaling arguments, strongly suggest that within the framework of resistive MHD, the nonlinear reconnection rate mediated by the plasmoid instability becomes insensitive to the value of S. Because the plasmoid instability can initiate a cascade to current sheets that are much thinner than the original Sweet-Parker sheet, the so-called Hall terms in the generalized Ohm's law become important, triggering the onset of Hall reconnection, which lead to higher reconnection rates. We will present recent results from the largest 2D Hall MHD simulations to date that demonstrate the rich dynamics enabled by the interplay between the plasmoid instability and the Hall current. It is shown that the topology of Hall reconnection is not inevitably a single stable X-point. There exists an intermediate regime where the single X-point topology itself exhibits instability, causing the system to alternate between a single X-point and an extended current sheet with multiple X-points produced by the plasmoid instability. Examples of applications will be drawn from laboratory, magnetospheric, and solar coronal plasmas.

Wednesday, January 18, 2012

Center Green 1, South Auditorium

Lecture at 1:30pm