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Current Sheet Shear Instability and its Role in 3D Magnetic Reconnection

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During quasi-steady reconnection, the current sheet profile is far from the Harris sheet. For the case of symmetric reconnection, the density profile is almost uniform, so that the pressure and current density profiles are maintained through the nonuniform temperature and bulk velocity profiles, respectively. Furthermore, the current sheet develops a two-scale structure consisting of the electron and ion current sheets.

The two-fluid linear analyses for the current sheet with uniform density profile have shown that there is a dominant kink-type mode having a spatiotemporal scale consistent with those in the 3D kinetic simulations [Fujimoto and Sydora, 2012]. It found, analytically, that the mode is driven by the flow shears of the electrons and ions, rather than the relative drift velocity between the species that leads to a drift-kink instability (DKI), previously analyzed for the Harris current sheet. This new instability is termed the current sheet shear instability (CSSI) and the linear theory and simulations demonstrate significant growth for realistic mass ratios compared to the DKI which is marginally stable. The CSSI is an interesting shear flow-type instability in the sense that it is generated by the electron flow shear but the mode scale length is controlled by the ions.

The CSSI generates waves with a scale intermediate between the ion and electron inertial length scales and it is capable of producing the momentum exchange between the species, resulting in an anomalous resistivity. In this presentation the focus is on the nonlinear saturation dynamics of the CCSI along with possible observational signatures in laboratory reconnection experiments and space plasma measurements in 3D magnetically reconnecting current layers.

References

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