DPP10-2010-000595

Abstract for an Invited Paper
for the DPP10 Meeting of
the American Physical Society

**Formation and Interaction of Flux Ropes in 3D Collisionless Magnetic Reconnection**

WILLIAM DAUGHTON, Los Alamos National Laboratory

Magnetic reconnection is important in a diverse range of applications including solar flares, geomagnetic substorms and a variety of astrophysical problems. For collisionless regimes, most kinetic studies have considered ion-scale current sheets using 2D models. These layers are unstable to the tearing instability which gives rise to the onset of reconnection and the formation of magnetic islands. As the dynamics develops, new electron-scale current layers are formed extending outwards from the diffusion regions, and these are often unstable to the formation of secondary islands. In this work, we demonstrate there are some profound differences in extending these previous 2D results to real 3D systems. With a finite guide field, tearing modes are unstable at resonant surfaces across the initial layer, corresponding to oblique angles relative to the standard 2D geometry. The 2D models artificially suppress these oblique modes and greatly restrict the manner in which magnetic islands can interact. In real 3D systems, both primary and secondary islands correspond to extended flux ropes, which can interact in a variety of complex ways not possible in 2D. Here, we address these challenges using Vlasov theory and 3D kinetic simulations. The linear stability of collisionless tearing is calculated using an exact integro-differential treatment, and these results are compared with an asymptotic approach to gain insight into the range of unstable oblique modes and the main parametric dependencies. The results are used to guide and interpret 3D kinetic simulations performed on two petascale computers (*Roadrunner* and *Kraken*). These unprecedented simulations, using up to 1.3 trillion particles, have revealed an inherently 3D evolution featuring the formation and interaction of flux ropes within the initial current layer, followed by the subsequent generation of secondary flux ropes within the elongated current sheets extending outward from the diffusion region as well as along the separatrices. These results may have far-reaching implications for a range of basic issues, including the structure of the exhaust, the dissipation rate of magnetic energy, the generation of stochastic magnetic fields and the transport of particles.