DPP11-2011-000481

Abstract for an Invited Paper
for the DPP11 Meeting of
the American Physical Society

First-order FLR effects on magnetic tearing and relaxation in pinch configurations[1]

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Drift and Hall effects on magnetic tearing, island evolution, and relaxation in pinch configurations are investigated using a non- reduced fluid model with first-order FLR effects. When the tearing-layer width is smaller than the ion sound gyroradius (ρ_s), cylindrical computations show that kinetic-Alfven- wave (KAW) physics increases linear growth rates relative to resistive MHD. An unexpected result with a uniform pressure profile is a drift effect that reduces the growth rate at intermediate-ρ_s values. This drift is present only with warm-ions FLR modeling, and analytics show that it arises from ∇B and poloidal curvature represented in the Braginskii gyroviscous stress. While the flux-surface average contribution from these drifts are small relative to diamagnetic drifts in tokamaks, they are dominant in pinch profiles. Growth rates and rotation frequencies are derived for a heuristic dispersion relation using the ion-drift effects and a resistive-MHD Ohm's law. This dispersion relation is in agreement with numerical results in the intermediate drift regime before KAW effects are significant. Nonlinear single-helicity computations with experimentally-relevant ρ_s values show that the warm-ion gyroviscous effects reduce saturated-island widths. In contrast to diamagnetic drift-tearing, the ∇B and poloidal curvature profiles are largely unaffected by magnetic islands. The result suggests an increasing tendency to obtain quasi-single helicity in reversed-field pinches with increasing ion temperature. [King et al., Phys. Pl. 2011] Multihelicity simulations show that both MHD and Hall dynamos contribute to relaxation events. The presence of Hall dynamo implies a fluctuation-induced Maxwell stress, and the simulation results show net transport of parallel momentum. The magnitude of force densities from the Maxwell stress and a competing Reynolds stress, and changes in the parallel-flow profile are within a factor of 1.5 of measurements [Kuritsyn et al., Phys. Pl. 2009] during a relaxation event in the Madison Symmetric Torus.

[1]Work supported by US DOE OFES and the NSF Physics Frontiers program.