Gyrokinetic Simulations of Tearing Instability

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The tearing instability is important in magnetic fusion devices, where it drives the formation of magnetic islands that can significantly degrade heat and particle confinement. The related micro-tearing mode may lead to background turbulence and is also a source of confinement loss. Solar flares and substorms in the Earth's magnetosphere are some of the many other contexts where tearing plays a crucial role, inducing magnetic reconnection, explosive energy release and large scale reconfiguration of the magnetic field.

In this study, we report linear gyrokinetic simulation results covering the collisional—collsionless transitional regime of the tearing instability[1] using AstroGK[2] astrophysical gyrokinetics code. It is shown that the growth rate scaling with collisionality agrees well with that predicted by a two-fluid theory for a low plasma beta case in which ion kinetic dynamics are negligible. Electron wave-particle interactions (Landau damping), finite Larmor radius effects, and other kinetic effects invalidate the fluid theory in the collisionless regime, in which a general non-polytropic equation of state for pressure (temperature) perturbations should be considered. We also vary the ratio of the background ion to electron temperature ratio, and show that the scalings expected from existing calculations can be recovered, but only in the limit of very low beta.

[1] Numata R, Dorland W, Howes, G G, Loureiro N F, Rogers B N, Tatsuno T, 2011 accepted for publication in Phys. Plasmas.
[2] Numata R, Howes G G, Tatsuno T, Barnes M, Dorland W, 2010 J. Comput. Phys **229**, 9347