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Non-linear 3D kinetic modeling of the internal kink instability

ADAM STANIER, WILLIAM DAUGHTON, ANDREI SIMAKOV, ARI LE, LUIS CHACON, Los Alamos National Laboratory — Flux-ropes are ubiquitous in magnetized plasmas and often undergo kink instabilities. The macroscopic kink motion can generate a helical current sheet where magnetic field-lines reconnect. Kink instabilities are typically studied with magnetohydrodynamic (MHD) models, but the validity of these models can break down in weakly collisional space and laboratory plasmas. Questions remain concerning the coupling between the macro-scale MHD drive and the detailed kinetic physics of the reconnection layer in these regimes. Here we present a 3D non-linear kinetic simulation of the m=1 internal kink instability in a straight tokamak. The helical current layer forms with macroscopic length and electron-scale thickness before breaking up via the collisionless plasmoid instability. Secondary flux-ropes generate stochastic magnetic field regions around the X-point and the m=1 island, and we track significant electron mixing in these regions. Due to strong macroscopic drive and weak magnetic shear, a 'quasi-interchange'-like bubble propagates to the plasma core where it deforms the m=1 island and leads to turbulence in a significant volume of the plasma column. We compare these results with 2D (helical) and 3D MHD simulations.

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