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Stability Properties of Field-Reversed Configurations [1]

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Abstract

New computational results are presented which advance the understanding of the stability properties of the Field-Reversed Configuration (FRC). We present results of hybrid and two-fluid (Hall-MHD) simulations of prolate FRCs in strongly kinetic and small-gyroradius, MHD-like regimes. The n=1 tilt instability mechanism and growth rate reduction mechanisms are investigated in detail including nonlinear and resonant particle effects, finite Larmor radius and Hall stabilization, and profile effects. It is shown that the Hall effect determines the mode rotation and the change in the linear mode structure in the kinetic regime; however, the reduction in the growth rate is mostly due to finite Larmor radius effects. Resonant wave-particle interactions are studied as a function of (a) elongation, (b) the kinetic parameter S*, which is proportional to the ratio of the separatrix radius to the thermal ion Larmor radius, and (c) the separatrix shape. It is demonstrated that, contrary to the usually assumed stochasticity of the ion orbits in the FRC, a large fraction of the orbits are regular in long configurations when S* is small. A stochasticity condition is found, and a scaling with the S* parameter is presented. Resonant particle effects are shown to maintain the instability in the large gyroradius regime. The nonlinear evolution of unstable modes in both kinetic and small-gyroradius FRCs is shown to be considerably slower than that in MHD simulations. Our simulation results demonstrate that a combination of kinetic and nonlinear effects is a key for understanding the experimentally observed FRC stability properties.

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