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Kinetic Stability of Alpha Driven TAEs in ITER Plasmas[1]

YANG CHEN, University of Colorado at Boulder

A hybrid gyrokinetic ions/fluid electron model is implemented in the Particle-in-Cell code GEM and used to study high-n TAEs in ITER. The adequacy of the model for simulating TAEs has been previously demonstrated[2], by comparing the simulated TAE mode frequency and structure with an eigenmode analysis, and the thermal ion kinetic damping with analytic theory. By using a global PIC code the effects of large orbit width and non-local mode structures can be accurately included. Damping rate due to numerical filtering is carefully monitored, and convergence with respect to particle number, grid resolution, etc., is thoroughly tested. The simulations show that the most unstable modes in ITER lie in the rage of $10 < n < 20$. Thermal ion pressure effect and alpha particles non-perturbative effect are important in determining the mode radial location and stability threshold. The thermal ion Landau damping rate and radiative damping rate from the simulations are compared with analytical estimates, with the former found to be dominant. Plasma elongation has a strong stabilizing effect. The central alpha particle pressure threshold for the most unstable n=15 mode is about $\beta_\alpha(0) = 0.7\%$ for the fully shaped ITER equilibrium. Nonlinear simulations are carried out to determine the saturation amplitude of unstable eigenmodes and the induced alpha particle transport. A kinetic closure scheme for the electron pressure terms in the electron fluid equations will be described.

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[2]J. Lang, Y. Chen, S. E. Parker, and G-Y. Fu, Phys. Plasmas 16 102101 (2009)