DPP15-2015-000409

Abstract for an Invited Paper
for the DPP15 Meeting of
the American Physical Society

Gyrokinetic Simulation of Low-n Tearing Modes

YANG CHEN, University of Colorado at Boulder

Direct gyrokinetic simulation of the low-n tearing mode in a tokamak plasma has been a great computational challenge, for two reasons. First, low-n tearing modes, unlike the micro-tearing modes, have very small growth rates and very fine mode structure in the tearing layer, which requires a large number of radial grid cells and fine control of numerical dissipation. Second, kinetic electron effects are needed in the tearing layer. Here, we first present linear gyrokinetic simulation of the low-n tearing mode in cylindrical geometry. Ions are gyrokinetic and electrons are either drift kinetic or fluid. New field solvers have been developed in the gyrokinetic code GEM [Chen and Parker, J. Comput. Phys. 220, 839 (2007)] to simulate low-n modes. For the fluid electron model, an eigenmode analysis with finite Larmor radius effects has been developed to study the linear resistive tearing mode. Excellent agreement between eigenmode analysis and initial value gyrokinetic simulation is obtained. The mode growth rate is shown to scale with resistivity as $\eta^{1/3}$, the same as the semi-collisional regime in previous kinetic treatments. Simulation of the collisionless and semi-collisional tearing mode with drift kinetic electrons has been carried out with GEM's direct split-weight control-variate algorithm. It is found that a full torus simulation of the m=2, n=1 tearing mode in a present day large tokamak is still difficult with kinetic electrons, but a generalized matching technique can be used to ameliorate the problem. The radial dimension is divided into an external region and the tearing region, with the external region described by a reduced model that gives the boundary condition for the tearing region. The size of the tearing region is small compared with the minor radius, but not arbitrarily small as done in the standard asymptotic matching approach. Gyrokinetic simulation verifies the collisionless tearing mode growth rate with finite electron mass, the semi-collisional linear growth rate, as well as the nonlinear scaling of particle trapping frequency with linear growth rate in the collisionless regime. Nonlinear results including collisions show that the mode initially saturates at low amplitude, followed by an algebraic growth period (the Rutherford regime). Current progress on simulating the low-n toroidal tearing mode in toroidal geometry will be reported.