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I1.104 Extended magnetohydrodynamic hybrid simulations with kinetic thermal and fast ions for instabilities in toroidal plasmas

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Magnetohydrodynamics (MHD) is a theoretical framework that explains well the macroscopic plasma behaviours. However, MHD is an unfinished framework for magnetically confined plasmas, because the MHD pressure equation assumes sufficiently high collision frequency which is not valid for the high-temperature plasmas. One typical example that needs an extension of MHD is energetic-particle driven instabilities. Kinetic-MHD hybrid simulations for energetic particles interacting with an MHD fluid are useful tools to understand and predict energetic particle driven MHD instabilities. We present a new hybrid simulation model where the gyrokinetic particle-in-cell simulation method is applied to both thermal and fast ions. It has been known that the Large Helical Device (LHD) plasmas are more stable for pressure driven MHD instabilities than MHD theory predicts [2]. We have applied the new simulation to the ballooning instabilities in LHD. Figure 1 demonstrates that the kinetic response of thermal ions to the MHD perturbations is significantly weaker than the adiabatic electron fluid response leading to the stabilization of the instability. The detailed particle dynamics in the nonaxisymmetric magnetic field that stabilizes the instability will be presented. In addition, the time evolutions of Alfvén eigenmodes (AEs) in tokamak plasmas and energetic particle driven geodesic acoustic modes (EGAMs) in LHD plasmas shown in Fig. 2 are simulated with kinetic thermal ions. It is demonstrated that fast-ion energy is transferred to thermal ions through the nonlinear interaction with the AEs and the EGAMs.

[1] Y. Todo and T. Sato, Phys. Plasmas 5 (1998) 1321.
[2] N. Nakajima et al., J. Plasma Fusion Res. 6 (2004) 45.

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