Abstract for an Invited Paper
for the DPP07 Meeting of
The American Physical Society

Nonlinear Hybrid Simulations of Multiple Energetic Particle driven Alfven Modes in Toroidal Plasmas[1]

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Understanding of nonlinear behavior of energetic particle-driven instabilities in tokamaks is of fundamental importance for burning plasmas. Here we report recent advances in self-consistent nonlinear simulations of fast beam ion-driven Alfven modes in NSTX and DIII-D using the extended MHD code M3D [1]. In the hybrid model, the thermal electrons and ions are treated as an ideal fluid while the energetic species is described by either drift-kinetic equation or gyrokinetic equation. The effects of energetic particles are coupled to the MHD equations via the stress tensor term in the momentum equation. The hybrid code has been recently applied to study nonlinear dynamics of fishbone instability [2]. The code was also used to simulate nonlinear evolution of a single beam-driven TAE mode in NSTX. The result showed a weak frequency chirping about 20% consistent with experimental measurement [3]. In this work, we use the M3D code to simulate beam ion driven Alfven modes in NSTX plasmas with multiple unstable Alfven modes. It is found that mode saturation level of each mode can be enhanced significantly by presence of other unstable modes indicating strong nonlinear interaction between different modes. It is also found that a linearly stable n=2 mode can be nonlinearly driven by an n=1 mode at significant mode amplitude. These results together with simulation results of beam ion-driven Alfven modes in DIII-D reversed shear plasmas [4] will be presented.

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[1]This work has been conducted under DOE Contract No. DE-AC02-76-CH3073