Global Hybrid Simulations of Energetic Particle-driven Modes in Toroidal Plasmas*

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The energetic particle-driven MHD modes are studied using hybrid model of the M3D code[1]. In the hybrid model, the plasma is divided into the bulk part and the energetic particle component. The bulk plasma is treated as a single fluid and the energetic particles are described by gyrokinetic particles. The previous version of the M3D code was mainly applied to axisymmetric circular tokamak geometry. Recently we have extended the M3D code to full 3D geometry using unstructured mesh in poloidal planes and finite difference in toroidal direction. The code has been parallelized so it can run in parallel using MPI. These new capabilities enable us to simulate energetic particle-driven MHD modes in advanced tokamaks, spherical tokamaks and stellarators for realistic parameters. First, the energetic particle-driven MHD modes in the National Spherical Tokamak Experiments (NSTX) are studied. Neutral Beam Fast Ion-driven modes in the TAE frequency range were observed in the NSTX plasmas. Both steady state and bursting modes were seen depending on experimental conditions. The goal of this study is to understand the nonlinear dynamics of the fast ion-driven MHD modes in a spherical tokamak plasma. Our simulation results show unstable TAEs with mode number $n = 2 \sim 4$ and mode frequencies consistent with the experimental observation. Initial nonlinear simulation results indicate that the mode frequency chirps down as the modes move out radially. Second, fast ion-driven Alfven modes in quasi-axisymmetric stellarators are studied. For a two period stellarator, results show an unstable global TAE mode with $n = 1$ as the dominant toroidal mode number. The effects of 3D shape is found to be stabilizing. Third, alpha-driven TAE/EPM and alpha particle effects on internal kink mode in burning plasmas are studied. Initial results indicate high-n TAE/EPM are stable in FIRE. Details of the simulations will be presented.

References

[1] W. Park, E.V. Belova, G.Y. Fu, X.Z. Tang, H.R. Strauss, L.E. Sugiyama, Phys. Plasmas **6** 1796 (1999)

*Supported by DOE DE-AC02-76-CHO-3073.

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