Gyrokinetic δf particle simulation of energetic particles driven modes

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Abstract

The GEM code, with kinetic electrons and electromagnetic perturbations implemented for equilibria of shaped magnetic flux surfaces, can in principle be used to study energetic particles driven MHD modes such as the Toroidicity-Induced Alfven Eigenmodes. Using a low-n global TAE as a test case [1], GEM simulation indeed shows the existence of a global discrete eigenmode. However, the observed frequency ($0.35\Omega_A$) is below the expected TAE frequency ($0.5\Omega_A$). We suspect that the discrepency is caused by the nonzero parallel electric field in GEM, which is likely amplified due to the reduced proton-to-electron mass ratio ($m_p/m_e = 500$) used in GEM simulations of MHD scale modes. We are currently studying the same problem with a hybrid model with gyrokinetic ions and massless fluid electrons, implemented in GEM. The fluid electron model consists of the electron continuity equation, parallel Ohm's law and a closure equation for the electron temperature. This model can be reduced to the exact MHD eigenmode equation when electron pressure is neglected in the Ohm's law, making a direct comparison with MHD results possible. Preliminary simulation again shows the existence of low-n global eigenmode, but the observed frequency still differs from the theoretical TAE frequency. Including an energetic particle species results in a different mode with different mode characteristics, which appear to be an Enertic-Particle-Driven (EPM) mode. In this presentation we will further characterize the observed eigenmodes - with kinetic electrons or fluid electrons, and with energetic particles - and attempt to resolve the discrepency between observations and theoretical predictions.

References

[1] G. Y. Fu and J. W. Van Dam, Phys. Fluids B 1, 1949 (1989)