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M3D-K Simulations of Beam-Driven Alfven Modes in DIIID

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Multiple beam-driven Reversed Shear Alfven eigenmodes (RSAEs) and Toroidal Alfven Eigenmodes (TAE) were observed in the DIII-D discharge (#142111) [1]. Extensive hybrid simulations with the global kinetic/MHD hybrid code M3D-K [2] have been carried out to investigate these beam-driven Alfven eigenmodes using experimental parameters and profiles from this discharge. The purpose of this work is for code verification and validation as well as for physics understanding needed for predicting energetic particle-driven instabilities and energetic particle transport in burning plasmas. We first benchmark M3D-K code with the linear ideal MHD stability code NOVA. The M3D-K results agree well with those of NOVA with respect to mode structure and mode frequency in the MHD limit. With energetic beam ions, the simulations results show that the destabilized n=3 mode transit from RSAEs to TAEs as the minimum of the safety factor drops in agreement with the measured frequency sweeping. The calculated 2D mode structure in poloidal cross-section exhibits a twisting feature or radial phase shearing consistent with the Electron Cyclotron Emission Imaging (ECEI) data [1]. An analytic theory has been developed to explain the radial phase shearing observed in the simulations and experiments. It is found that both the fast ion drive and background damping can cause radial phase shearing. The direction of phase shearing changes when the toroidal magnetic field is reversed whereas the shearing direction is independent of plasma current direction. This symmetry agrees with the experimental observation from ECEI. Finally, nonlinear simulations of the beam-driven modes with particle collision and particle source and sink have been carried out and results show that other Alfven modes becomes destabilized after the initial saturation of the n=3 RSAE mode. The details of the linear and nonlinear simulation results will be presented.

[1] B. J. Tobias *et al.*, Phys. Rev. Lett. **106**, 075003 (2011).
[2] G.-Y. Fu et al., Phys. Plasmas **13**, 052517 (2006).