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Numerical Modeling of NBI-driven sub-cyclotron frequency modes in NSTX[1]

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Recent experimental observations from NSTX suggest that many modes in a sub-cyclotron frequency range are excited during neutral beam injection (NBI). As was shown recently, these modes are capable of channeling the beam ion energy into the thermal ions, and they can also induce strong anomalous electron transport in STs. These modes were identified as Compressional Alfven Eigenmodes (CAEs) and Global Alfven Eigenmodes (GAEs), driven unstable through the Doppler shifted cyclotron resonance with the super Alfvenic NBI ions. Hybrid 3D code HYM is used to investigate detailed properties of beam ion driven MHD modes in NSTX, aiming at simulations of plasmas where GAE and CAE modes have been observed. The HYM code is a nonlinear, global stability code in toroidal geometry, which includes fully kinetic ion description. A generalized form of the Grad-Shafranov equation solver has been developed, which includes, non-perturbatively, the effects of the beam ions with anisotropic distribution. For large neutral beam injection velocities and strong anisotropy in the pitch-angle distribution, many Alfven modes are excited in simulations. The resonant particles are shown to satisfy Doppler-shifted cyclotron resonant conditions, and multiple resonances are found for each toroidal mode number. Growth rates of GAE modes are sensitive to details of the distribution function, in particular, the pitch angle distribution. Nonlinear simulations show that GAE instabilities saturate at low amplitudes due to particle trapping. Most unstable mode toroidal numbers, frequencies, and saturation amplitudes in HYM simulations agree with experimental results for NSTX. The magnetic perturbations have shear Alfven wave polarization in the core, however the compressional component dominates at the edge in agreement with magnetic measurements in the NSTX.

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