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Energy Channeling and Coupling of Neutral-beam-driven Compressional Alfvén Eigenmodes to Kinetic Alfvén Waves in NSTX[1]

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Experimental observations from the National Spherical Torus Experiment (NSTX) have linked strong activity of global (GAEs) and compressional (CAEs) Alfven eigenmodes with a flattening of the electron temperature profile in beam heated plasmas in NSTX [1]. Previous theoretical studies attributed this effect to an enhanced electron transport due to these modes [2]. This work presents the first self-consistent simulations of neutral-beam-driven CAEs demonstrating an important alternative, an efficient energy channeling mechanism that will occur for any unstable CAE in NSTX or other toroidal devices. Three-dimensional hybrid MHD-particle simulations using the HYM code for an NSTX discharge (141398) show unstable CAEs for a range of toroidal mode numbers, n=4-9, and frequencies below the ion cyclotron frequency. It is found that an essential feature of CAE modes in NSTX is their coupling to kinetic Alfven waves (KAW) that occurs on the high-field side at the Alfven resonance location. The radial width of the KAW is found to be comparable to the fast ion Larmor radius. The beam-driven CAE can mode-convert to KAW, channeling energy from the beam ions at the injection region near the magnetic axis to the location of the resonant mode conversion at the edge of the beam density profile. This mechanism can explain the reduced heating of the plasma core in NSTX. The NBI power transferred to one CAE has been estimated as up to P=0.4MW, based on measured displacement amplitudes and HYM calculated mode structure. The energy flux from the CAE to the KAW and dissipation at the resonance location can have a direct effect on the temperature profile with changes in core electron temperature up to several hundred eV. It is shown that strong CAE/KAW coupling follows from the dispersion relation, and will occur for any unstable CAE in NSTX or other toroidal devices, independent of toroidal mode number or mode frequency.

[1] D. Stutman, et al., Phys. Rev. Lett. **102**, 115002 (2009).
[2] N.N. Gorelenkov, D. Stutman, K. Tritz et al., Nucl. Fusion **50** 084012 (2010).

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