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Theory for control of sub-cyclotron Alfvén instabilities and implications for anomalous electron energy transport in tokamaks[1]

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New numerical and analytic results significantly advance understanding of the destabilization and suppression of beam-driven sub-cyclotron compressional (CAE) and global (GAE) Alfvén eigenmodes in tokamaks. These instabilities have been experimentally linked to the anomalous flattening of electron temperature profiles at high beam power in NSTX [1]. In particular, CAEs/GAEs can effectively channel energy away from the core [2], resulting in presently unpredictable modifications to the core plasma heating. For this reason, CAEs and GAEs, which are routinely excited in spherical tokamaks such as NSTX(-U) and MAST, which have been observed on DIII-D, and which may be excited in ITER, must be considered when planning future burning plasma scenarios. A detailed understanding of CAE/GAE excitation, therefore, is vital to predicting and controlling their effects on plasma confinement. A comprehensive set of 3D hybrid MHD/particle simulations has been performed for a wide range of beam parameters, providing a wealth of information on CAE and GAE stability in realistic scenarios. Furthermore, a new analytic theory and stability conditions have been derived for CAEs and GAEs [3]. It describes key properties of the mode spectra generated in simulations and measured experimentally, explains the recent experimental discovery of GAE stabilization in NSTX-U [4], and resolves puzzling observations in DIII-D. New mechanisms for stabilization of CAEs and GAEs via multi-beam distributions are suggested and demonstrated numerically. The combined numerical and analytical approach presents a powerful predictive capability for effective control of these modes and the energy transport they induce. [1] Stutman PRL 102, 115002 (2009) [2] Belova PRL 115, 015001 (2015) [3] Lestz POP (submitted 2019) [4] Fredrickson PRL 118, 265001 (2018)

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