Gyrokinetic simulation of global and local Alfvén eigenmodes driven by energetic particles in a DIII-D discharge

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Abstract

The unstable spectrum of Alfvén eigenmodes (AEs) driven by neutral beam-sourced energetic particles (EPs) in a benchmark DIII-D discharge (142111) is calculated in a fully gyrokinetic model using the GYRO code's massively parallel linear eigenvalue solver. One cycle of the slow (equilibrium scale) frequency sweep of the reverse shear Alfvén eigenmode (RSAE) at toroidal mode number $n = 3$ is mapped. The RSAE second harmonic and an unstable beta-induced Alfvén eigenmode (BAE) are simultaneously tracked alongside the primary RSAE. An observed twist in the eigenmode pattern, caused mostly by shear in the driving EP profile, is shown through artificially varying the $\mathbf{E}\times\mathbf{B}$ rotational velocity shear to depend generally on shear in the local wave phase velocity. Coupling to the BAE and to the toroidal Alfvén eigenmode (TAE) limit the RSAE frequency sweep at the lower and upper end respectively. While the present fully gyrokinetic model (including thermal ions and electrons) constitutes the best treatment of compressibility physics available, the BAE frequency is overpredicted by about 20% against experiment here and is found to be sensitive to energetic beam ion pressure. The RSAE frequency is more accurately matched except when it is limited by the BAE. Simulations suggest the experiment is very close to marginal AE stability at points of RSAE-BAE coupling.

A recipe for comparing the radial profile of quasilinear transport flux from local modes to that from global modes paves the way for the development of a stiff (critical gradient) local AE transport model based on local mode stability thresholds.