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Comparison of energetic particle radial transport between single-n and multiple-n simulations of Alfvénic modes

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The results of a set of simulations of Alfvén modes driven by an energetic particle population are presented, with the specific aim of comparing energetic particle radial transport between single-n and multiple-n simulations. The hybrid reduced O(ϵ_0^3) MHD gyrokinetic code HMGC is used, retaining both fluid (wave-wave) and energetic particles nonlinearities. The code HMGC retains self-consistently, in the time evolution, the wave spatial structures as modified by the energetic particle (EP) term.
A model equilibrium has been considered, rather than a specific experimental device, with the aim of studying how the dynamics of the EP driven Alfvénic modes changes when considering single-n or multiple-n simulations, while keeping all the other parameters fixed. A circular, shifted magnetic surface, static equilibrium has been considered, characterized by a large aspect ratio ($\epsilon_0 = 0.1$) and a parabolic safety factor profile with $q_0 = 1.1$ and $q_a = 1.9$ being, respectively, the on-axis and edge safety factor. A bulk ion density profile $n_i(r) \sim (q_0/q(r))^2$ has also been assumed, in order to have the toroidal gap radially aligned, for all the mode considered. Regarding the EPs, an isotropic Maxwellian distribution function has been considered.
Simulations with toroidal mode numbers 1≤n≤15 have been considered. A variety of modes are observed (TAEs, upper and lower KTAEs, EPMs) during the linear growth phase. All the strongly unstable modes (4≤n≤12) exhibit pronounced (both up and down) frequency chirping at saturation. Nevertheless, no appreciable global modification of the energetic particle density profile is observed at saturation for the unstable modes.
On the contrary, multiple-n simulations, with the same Fourier toroidal mode spectrum of the set of single-n simulations, exhibit an appreciable broadening of the energetic particle radial density profile at saturation, thus showing an enhanced radial transport w.r.t. the single-n simulations. Moreover, the sub-dominant modes are strongly modified by the nonlinear coupling, which results both from the MHD and from the energetic particle terms. The present nonlinear simulations show that all the toroidal modes saturate almost simultaneously, after inducing an enhanced energetic particle radial transport. No evidence of the so-called "domino" effect is observed.

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