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Nonlinear stability of drift-tearing magnetic islands

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Abstract

The stability of drift-tearing magnetic islands in semi-collisional regimes is investigated on the basis of a fluid four-field model, which includes the effects associated with the electron compressibility and the ion motion along magnetic field lines. In a recent paper [1], we have shown that small-amplitude drift-tearing modes are stable even for positive and relatively large values of the tearing mode stability parameter, Δ', provided that the electron beta parameter, $\beta = (v_s/v_A)^2$, exceeds a threshold value determined by the electron drift wave frequency normalized to the Alfven frequency, ω_*/ω_A, and the normalized ion sound Larmor radius, $\rho = v_s/L_s\Omega_{ci}$. Here, $v_s = (T/m_i)^{1/2}$ is the sound speed, T is the electron temperature, $v_A = \omega_A L_s$ is the Alfven speed, L_s is the equilibrium magnetic shear length and Ω_{ci} is the ion cyclotron frequency. The electron beta parameter measures the strength of the coupling between drift-tearing modes and drift-acoustic waves, associated with the parallel ion motion.

In this presentation, the nonlinear stability properties are investigated numerically in regimes with positive Δ' of order unity. We find that magnetic islands of finite width can be suppressed for values of beta in the neighborhood of the linear threshold. Nearly steady-state magnetic island solutions obtained at zero β are such that the electron pressure gradient is somewhat reduced within the island region and the island is nearly stationary (i.e. non-rotating) in the plasma rest frame. Nevertheless, diamagnetic effects are felt nonlinearly, as these solutions exhibit a localized zonal flow comparable with the electron diamagnetic drift velocity associated with the equilibrium pressure gradient. Nonlinear numerical simulations are suggestive of a complex bifurcation diagram for these equilibrium solutions, depending on the ratio between the sound Larmor radius and the saturated island width, w_s, attained at $\beta = 0$. Magnetic islands are suppressed when this ratio is of order unity and the coupling to the parallel ion motion (i.e. finite beta) is switched on. Saturated islands persist at larger values of w_s/ρ, even when beta exceeds the linear threshold value. Thus, in these situations where linear stability theory indicates that small amplitude tearing perturbations are stable, sufficiently large initial perturbations can still develop into finite size magnetic islands.

[1] Grasso, D., Ottaviani, M., and Porcelli, F., *Nuclear Fusion* **42** (2002) 1-8.