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Nonlinear Evolution of Edge Localized MHD Instabilities: A Comparison of Peeling and Ballooning-Dominated Equilibria[1]

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Analytic and numerical techniques are employed to describe the nonlinear evolution properties of edge localized ideal MHD instabilities. It is shown that the nonlinear dynamics of these instabilities depend upon the nature of the linear ideal MHD instability drive. Edge-localized ideal MHD modes for two shifted-circle tokamak equilibria are examined nonlinearly using the extended-MHD code NIMROD. The equilibria have H-mode-like profiles with differing edge currents and pressure gradients to produce linear stability spectra that peak at low-n(peeling-like) and high-n(ballooning-like). Numerical simulations characterize the evolution from the linear to the intermediate nonlinear regime, which is characterized by an ideal MHD displacement amplitude comparable to the mode width. For the peeling-like plasma, an edge-localized, $n=0$, sheared cross-field plasma flow arises. As the instability enters the intermediate nonlinear regime the flow-shearing rate becomes comparable to the linear growth rate and nonlinearly slows the mode growth. This result is in sharp contrast to the ballooning-like equilibria where a smaller shear rate is generated and the mode grows exponentially with the linear growth rate well into the intermediate nonlinear regime [1]. The numerical results are consistent with an analytic theory derived to describe the nonlinear evolution properties of edge localized ideal MHD modes. A set of nonlinear evolution equations for the intermediate nonlinear phase of peeling mode instability is derived using the ratio of the radial mode width to the minor radius as an asymptotic expansion parameter. This differs from previous work on the nonlinear ballooning instability where a conventional ballooning order is used to derive the nonlinear evolution equations [1].

[1] P. Zhu, C.C. Hegna, and C.R. Sovinec, *Phys. Rev. Lett.* 102, 235003 (2009).

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