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Stability of Finite-*n* Edge-localized Modes

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High performance H–mode plasmas are often terminated or degraded by edge localized instabilities (ELMs). In addition to directly limiting performance, these ELMs can also inhibit the formation of internal transport barriers and produce large divertor heat pulses. Theoretical analysis of edge instabilities is complex, in part because the sharp pressure gradients and consequent large bootstrap currents near the H–mode edge can destabilize kink, peeling, and ballooning modes over a wide range of toroidal mode number (n). Previous studies of H-mode discharges using low-n kink and high-n ballooning stability codes suggest an important role for instabilities in the intermediate range of toroidal mode numbers ($3 < n < 40$). Here we present results from a stability study which extends over the full range of toroidal mode numbers, closing the gap at intermediate n, and allowing more complete predictions of ELM stability. The ELITE code, extended to general geometry, is used to study coupled peeling/ballooning stability at intermediate to high n. An enhanced version of the low-n stability code GATO, which applies the ballooning transformation to more efficiently treat higher n modes, is used at low to intermediate n. Accessibility of the second stability regime is found to play an important role in determining the character of edge instabilities. When high-n modes have second regime access, the edge plasma pressure gradient and current can rise to very high values, driving instabilities at lower n. Because finite-n effects are generally stabilizing, the first mode driven unstable is approximately the highest n without second access. When high-n modes do not have second access, finite Larmor radius and kinetic effects determine which mode will be driven unstable first. Theoretical stability predictions are compared with results from an experimental study of changes in ELM character with flux surface shape on the DIII–D tokamak.

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