Full Spectrum Stability Analysis of the Tokamak Edge Region*

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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 numbers (n). Previous studies [1] 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 spectrum of toroidal mode numbers, closing the gap at intermediate n, and allowing more complete predictions of ELM stability and edge pressure gradient limits. The ELITE code [2], designed to describe the coupled system of peeling and ballooning modes in the edge, is extended to general tokamak geometry and used to study edge stability at intermediate n. An enhanced version of the low-n GATO stability code, which applies the ballooning transformation to more efficiently treat higher n modes, is used at low to intermediate n, and a gyrokinetic code is employed at high n. Accessibility of the ballooning mode second stability regime is found to play an important role. 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 regime access. When high-n modes do not have second regime access, finite Larmor radius and kinetic effects determine the most unstable mode. 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. Nonlinear simulations using the Braginskii-based BOUT code, enhanced to include current driven modes, are planned to characterize the evolution of edge instabilities, including changes with flux surface shape.

[1] J.R. Ferron, *et. al.*, Bull. Am. Phys. Soc. **44**, 286 (1999), to appear in Phys. Plas.
[2] H.R. Wilson, *et. al.*, Phys. Plas. **6**, 1925 (1999).

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