IMPACT OF EDGE CURRENT DENSITY AND PRESSURE GRADIENT ON THE STABILITY OF DIII–D HIGH PERFORMANCE DISCHARGES*

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One of the major goals of advanced tokamak research is to develop plasma configurations with good confinement and improved stability at high β. In DIII–D, various high performance configurations with H– and VH–mode edges have been produced. These include discharges with poloidal cross sections in the forms of dee and crescent shapes, single- and double-null divertors, and with various central magnetic shear profiles and current profile peakedness. All these discharges exhibit enhanced confinement in the outer plasma region which leads to a large edge pressure gradient and a large edge current density. These edge conditions often drive an instability with toroidal mode number $n > 1$ near the edge region which can severely degrade the discharge performance. An understanding of this edge instability is essential to sustain and enhance the discharge performance.

The instability is localized both toroidally and poloidally in the bad curvature region with a fast growth time $\gamma^{-1} \approx$ 20–150 μs and usually rotates in the electron diamagnetic drift direction. The magnetic perturbation associated with this instability may consist of a single pulse with no precursor or may be preceded by a 1/1 mode depending on the q profile. The instability has been observed over a wide range of β_N = 2.5–5.0 including discharges with negative central magnetic shear and high ℓ_i. The attainable β appears to decrease with the fraction of plasma current contained in the edge region and is consistent with the previously observed operational limit of $\beta_N \approx 4\ \ell_i$. The effects of plasma shaping on the instability appear to be weak. The instability is observed in crescent shaped discharges with indentation ≈10% recently produced and in low triangularity single-null divertor discharges.

The results of ideal stability calculations are consistent with many observed features of the instability. Stability analysis using both experimental and simulated equilibria suggests that $n > 1$ modes are more unstable and the large edge pressure gradient and current density are the main driving forces. The results also suggest that high n ballooning modes near $\rho \approx$ 0.9 may play a role. The performance degradation may depend on the thickness of the steep pressure gradient region and its impact on the radial mode structure and the unstable toroidal mode number.

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