Predictive Capability of MHD Stability Limits in High Performance DIII-D Discharges

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Abstract

Results from an array of theoretical and computational tools developed to treat the instabilities of most interest for high performance tokamak discharges are described. The theory and experimental diagnostic capabilities have now been developed to the point where detailed predictions can be productively tested so that competing effects can be isolated and either eliminated or confirmed. The linear magnetohydrodynamic (MHD) stability predictions using high quality discharge equilibrium reconstructions are tested against the observations for the principal limiting phenomena in DIII–D: L–mode negative central shear (NCS) disruptions, H–mode NCS edge instabilities, and tearing and resistive wall modes (RWMs) in long pulse discharges. In the case of predominantly ideal plasma MHD instabilities, agreement between the code predictions and experimentally observed

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stability limits and thresholds can now be obtained to within several percent, and the predicted fluctuations and growth rates to within the estimated experimental errors. Edge instabilities can be explained by a new model for edge localized modes as predominantly ideal instabilities with low to intermediate toroidal mode number. Accurate ideal calculations are critical to demonstrating RWM stabilization by plasma rotation, and the ideal eigenfunctions provide a good representation of the RWM structure when the plasma rotation slows. Ideal eigenfunctions can then be used to predict stabilization using active feedback. For non-ideal modes, the agreement in some cases is promising; Δ' calculations, for example, indicate that some discharges are linearly unstable to classical tearing modes, consistent with the observed growth of islands in those discharges. Nevertheless, there is still a great deal of improvement required before the non-ideal predictive capability can routinely approach levels similar to that for the ideal comparisons.