Global MHD Mode Stabilization and Control for Disruption Avoidance

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The near-complete elimination of plasma disruptions in fusion-producing tokamaks is the present "grand challenge" for stability research. Meeting this goal requires multiple approaches, important components of which are prediction, stabilization, and control of global MHD instabilities. Research on the recently-operating NSTX-U starts a plan of synergizing these elements to make quantified progress on this challenge. Initial results from disruption characterization and prediction analyses describe physical disruption event chains in plasmas from the existing NSTX database. Analysis of NSTX and DIII-D experiments show that understanding of the stabilization of global modes is unified by kinetic RWM stabilization theory with an interesting complementarity: enhanced stability is dominated by precession drift in NSTX and bounce orbit resonances in DIII-D. Stability therefore depends on the plasma rotation profile. A model-based rotation profile controller for NSTX-U using both neutral beams and neoclassical toroidal viscosity is shown in simulations to evolve profiles away from unstable states. Active RWM control is addressed using dual field component sensor feedback and a model-based RWM state-space controller. Comparison of measurements and synthetic diagnostics is examined for off-normal event handling. A planned 3D coil system upgrade can allow RWM control close to the ideal $n = 1$ with-wall limit. The initial plasma reconstructions generated in the NSTX-U device will be shown, presenting the status, challenges, and advantages of reconstructing low aspect ratio equilibria for use in the stability and control calculations needed for disruption prediction and avoidance.

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