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The Role of Kinetic Effects, Including Plasma Rotation and Energetic Particles, in Resistive Wall Mode Stability[1]

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Continuous, disruption-free operation of tokamaks requires stabilization of the resistive wall mode (RWM). Theoretically, the RWM is thought to be stabilized by energy dissipation mechanisms that depend on plasma rotation and other parameters, with kinetic effects being emphasized.[3] Experiments in NSTX show that the RWM can be destabilized in high rotation plasmas while low rotation plasmas can be stable, which calls into question the concept of a simple critical plasma rotation threshold for stability. The present work tests theoretical stabilization mechanisms against experimental discharges with various plasma rotation profiles created by applying non-resonant n=3 braking, and with various fast particle fractions. Kinetic modification of ideal stability is calculated with the MISK code, using experimental equilibrium reconstructions. Analysis of NSTX discharges with unstable RWMs predicts near-marginal mode growth rates. Trapped ions provide the dominant kinetic resonances, while fast particles contribute an important stabilizing effect. Increasing or decreasing rotation in the calculation drives the prediction farther from the marginal point, showing that unlike simpler critical rotation theories, kinetic theory allows a more complex relationship between plasma rotation and RWM stability. Results from JT-60U show that energetic particle modes can trigger RWMs[4]. Kinetic theory may explain how fast particle loss can trigger RWMs through the loss of an important stabilization mechanism. These results are applied to ITER advanced scenario equilibria to determine the impact on RWM stability.

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[2]With S.A. Sabbagh, H. Reimerdes, R. Betti, and B. Hu.
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[4]G. Matsunaga et al., IAEA FEC 2008 Paper EX/5-2.