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Resistive Wall Mode Stabilization by Slow Plasma Rotation in DIII-D Tokamak Discharges with Balanced Neutral Beam Injection[1]

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Recent DIII-D experiments show that, with low magnetic field errors, the plasma rotation threshold for stable operation above the no-wall beta limit is more than a factor of 2 lower than previously reported. A key feature is that slow plasma rotation is achieved by reducing the neutral beam torque, using DIII-D's new capability for mixed co and counter injection. In the presence of a nearby resistive wall, the ideal kink instability that often limits beta in tokamaks becomes a slowly growing resistive wall mode (RWM), which can be stabilized by sufficiently rapid rotation of the plasma. Previous experiments [1-4] indicated that RWM stability required a minimum plasma rotation velocity, evaluated at the $q = 2$ surface, of at least 0.6% of the local Alfven speed, consistent with theoretical modeling [2,4,5]. Those experiments combined strong, uni-directional neutral beam torque with magnetic braking by intrinsic or applied magnetic perturbations to slow the plasma, and resonant effects of the perturbation may have led to a larger rotation threshold. In contrast, recent DIII-D discharges with low torque and minimal nonaxisymmetric field errors have stably exceeded the no-wall beta limit by more than 30% with ion rotation velocity (from C-VI emission) less than 0.3% of the Alfven speed at the $q = 2$ surface. These results challenge the leading RWM stabilization theories and suggest that wall stabilization of high beta plasmas in ITER and other future devices may be possible with modest rotation, if resonant perturbations are minimized.

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