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Sustained Rotational Stabilization of DIII-D Plasmas Above the No-Wall Beta Limit[1]

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Sustained stabilization of the n=1 kink mode by plasma rotation at beta approaching twice the stability limit calculated without a wall has been achieved in DIII-D by a combination of error field reduction and sufficient rotation drive. Previous experiments have transiently exceeded the no-wall beta limit, but demonstration of sustained rotational stabilization has remained elusive. Recent theory[2] predicts a resonant response to error fields in a plasma approaching marginal stability to a low-n kink mode. Enhancement of magnetic non-axisymmetry in the plasma leads to strong damping of the toroidal rotation, precisely in the high-beta regime where it is needed for stabilization. This "error field amplification," EFA, is demonstrated in DIII-D experiments: applied n=1 error fields cause enhanced plasma response and strong rotation damping at beta above the no-wall limit, but have little effect at lower beta. The discovery of EFA has led to sustained operation above the no-wall limit through improved error field correction using an external coil set. The required correction is determined both by optimizing the external currents with respect to the plasma rotation, and by use of feedback to detect and minimize the plasma response to error fields as beta increases. Stability analysis and rotation braking experiments at different beta values show that beta is maintained 50% higher than the no-wall stability limit for duration greater than 1 second, and approaches beta twice the no-wall limit in several cases, with steady-state rotation levels. The results suggest that improved error field correction could allow plasmas to be maintained well above no-wall beta limit for as long as sufficient torque is provided.

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[2]A. Boozer, Phys. Rev. Lett. **86**, 5059 (2001).