

MHD Stability in a Tokamak Above the Free Boundary Pressure Limit

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Abstract

Sustained, stable plasma operation at high pressure above the free boundary limit for the $n=1$ ideal MHD external kink mode has been achieved in DIII-D with a combination of high plasma rotation and a resistive wall close to the plasma surface. The no-wall limit theoretically predicted for a number of plasma configurations has been tested to unprecedented accuracy ($\pm 5\%$) using a technique that exploits the stability properties of the resistive wall mode (RWM). Magnetic braking of the plasma rotation leads to an RWM-induced beta collapse at beta just above the predicted no-wall limit, while it has virtually no effect on the plasma at beta just below the no-wall limit. At twice the free-boundary pressure limit, a disruption precursor is observed, which is consistent with having reached the "ideal wall" pressure limit predicted by stability calculations. At beta below the no-wall limit, the negative growth rate of the RWM has been measured using a low-frequency analog of the active MHD measurements carried out for Alfvén Eigenmodes on JET [1]. A quasi-DC pulse of $n=1$ magnetic field is applied externally at different beta values. A forced, resonant, plasma response and strong rotation damping are observed at beta above the no wall limit, while a response about the noise level is observed at lower beta. Acting like an "adaptive magnetics" system, the resistive wall mode feedback system in DIII-D can exploit the strong plasma response to external $n=1$ fields as beta exceeds the no-wall limit, to serve as an indicator of the presence of small magnetic field asymmetries. In closed loop, the system is able to drive appropriate correction fields. These corrections are necessary to sustain the plasma rotation above the threshold for stabilization of the RWM.

[1] Fasoli, A., *et al.*, Phys. Rev. Lett. **75** (1995) 645

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