Abstract for an Invited Paper
for the DPP06 Meeting of
The American Physical Society

Active Resistive Wall Mode Stabilization in Low Rotation, High Beta NSTX Plasmas[1]

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An active feedback system to stabilize the resistive wall mode (RWM) in the National Spherical Torus Experiment (NSTX) is used to maintain plasma stability for greater than 90 RWM growth times. These experiments are the first to demonstrate RWM active stabilization in high beta, low aspect ratio tokamak plasmas with toroidal plasma rotation significantly below the critical rotation profile for passive stability and in the range predicted for ITER. Actively stabilized, low rotation plasmas reached normalized beta of 5.6, and the ratio of normalized beta to the toroidal mode number, n = 1 and 2 ideal no-wall stability limits reached 1.2 and 1.15 respectively, determined by DCON stability analysis of the time-evolving reconstructed experimental equilibria. The significant, controlled reduction of the plasma rotation to less than one percent of the Alfven speed was produced by non-resonant magnetic braking by an applied n = 3 field. The observed plasma rotation damping is in quantitative agreement with neoclassical toroidal viscosity theory including trapped particle effects [1]. The active stabilization system employs a mode control algorithm using RWM sensor input analyzed to distinguish the amplitude and phase of the n = 1 mode. During n = 1 stabilization, the n = 2 mode amplitude increases and surpasses the n = 1 amplitude, but the mode remains stable. By varying the system gain, and relative phase between the measured n = 1 RWM phase and the applied control field, both positive and negative feedback were demonstrated. Contrary to past experience in moderate aspect ratio tokamaks with poloidally continuous stabilizing structure, the RWM can become unstable in certain cases by deforming poloidally, an important consideration for feedback system sensor and control coil design in future devices such as ITER and KSTAR.
**In collaboration with R.E. Bell, J.E. Menard, D.A. Gates, A.C. Sontag, J.M. Bialek, B.P. LeBlanc, F.M. Levinton, K. Tritz, H. Yuh.
[1] W. Zhu, S.A. Sabbagh, R.E. Bell, et al., *Phys. Rev. Lett.* **96**, 225002 (2006).

[1]Work supported by U.S. DOE Contracts DE-FG02-99ER54524 and DE-AC02-76CH03073.