RWM Stabilization and Maintenance of High Beta Plasmas in NSTX*

S.A. Sabbagh[1], J.W. Berkery[1], S.P. Gerhardt[2], J.M. Bialek[1], R.E. Bell[2], R. Betti[3], L. Delgado-Aparicio[2], D.A. Gates[2], B.P. LeBlanc[2], J. Manickam[2], J.E. Menard[2], K. Tritz[4]

[1]*Dept. of Applied Physics and Applied Mathematics, Columbia U., New York, NY, USA*
[2]*Princeton Plasma Physics Laboratory, Princeton U., Princeton, NJ, USA*
[3]*Laboratory for Laser Energetics, University of Rochester, Rochester, NY, USA*
[4]*Johns Hopkins University, Baltimore, MD, USA*

Maintaining steady fusion power output at high plasma beta is an important goal for future burning plasmas such as in ITER advanced scenario operation and a spherical torus component test facility. Plasmas in the National Spherical Torus Experiment (NSTX) have exceeded plasma normalized beta of 7 transiently. Present research investigates the stability physics and control to maintain steady high normalized beta greater than 5. Combined n = 1 resistive wall mode (RWM) control and new beta feedback capability are used to generate high pulse-averaged normalized beta with low fluctuation. Non-resonant magnetic braking by applied 3-d fields due to neoclassical toroidal viscosity (NTV) is used to alter plasma rotation compatibly with beta feedback, producing long pulse duration at varied rotation levels. RWM instability can occur at relatively high rotation levels. Analysis using the MISK code shows a region of reduced RWM stability for marginally stable experimental plasmas caused by the rotation profile falling between stabilizing ion precession drift and bounce resonances. [1] Calculations for ITER show that alpha particles are required to stabilize the RWM at anticipated rotation levels for normalized beta of 3. Non-resonant NTV braking could be used to actuate rotation control and avoid profiles unfavorable for stability. As ExB frequency is reduced, NTV torque is expected to increase as collisionality decreases, and maximize when it falls below the grad(B) drift frequency (superbanana plateau regime) [2]. Increased non-resonant braking was observed at constant applied field and normalized beta in experiments when rotation and ExB frequency were reduced to low values. The newly-developed multi-mode VALEN code is used to analyze high normalized beta experiments showing evidence of driven RWM activity. Growth rates, computed vs. normalized beta, are in the observed experimental range. The computed eigenfunction spectrum comprising the perturbed field shows significant multi-mode content. Multi-mode RWM stability is determined for ITER advanced scenario plasmas at normalized beta sufficient to destabilize n = 2 modes.

*Supported by US DOE Contracts DE-FG02-99ER54524 and DE-AC02-09CH11466.

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