

“Progress in MHD science and the development of operational scenarios on the National Spherical Torus Experiment (NSTX)[†]”

D. A. Gates¹, J. E. Menard¹, S. A. Sabbagh², Aaron Sontag² - and the NSTX national research team

¹Princeton Plasma Physics Laboratory, Princeton University, Princeton NJ, 08540

²Columbia University, New York, NY 10027

NSTX has as its overarching goal “...assessing the attractiveness of the spherical torus as a fusion energy concept, both as the centerpiece of a fusion reactor and as a neutron source for a component test facility”. An important part of this mission is the determination and optimization of limits to achievable the plasma pressure imposed by large-scale magneto-hydrodynamic (MHD) instabilities. To this end, NSTX has recently installed a set of six window-pane coils designed to create radial magnetic fields at the device midplane. Three independent power supplies can be connected to these coils in either an n=odd or an n=even configuration. This new experimental capability has been used for feedback on the n=1 resistive wall mode (RWM). The coils were simultaneously used to help generate the RWM by applying an n=3 static field to slow plasma rotation (“magnetic braking”). This magnetic braking capability has also been used to explore the physics of RWM rotation by investigating the scaling of the rotation damping during braking experiments. Results of these experiments will be presented. In addition, these non-axisymmetric coils can be used to correct existing error fields. Recent experiments have been performed to correct an observed n=1 field error. Measurements indicate that the observed error is proportional to the product of the currents in the ohmic heating transformer and the toroidal field coil. In combination with feedback, an algorithm designed to correct for this error has been successfully used to double the pulse length of otherwise disruptive scenarios by maintaining the plasma rotation above the RWM critical rotation frequency.

The spherical torus concept relies heavily on the bootstrap current in order to maintain plasma current in the absence of a large transformer. In addition, the cost of fusion power is strongly affected by the recirculating power fraction due to the normally conducting toroidal field coil. This additional constraint necessitates operating with high plasma toroidal β_t , where $\beta_t = 2\mu_0\langle p \rangle / B_t^2$ with $\langle p \rangle$ the volume averaged plasma pressure, and B_t the toroidal field at the plasma geometric center. A useful figure of merit that combines these 2 parameters is $f_{bs}\beta_t$ where $f_{bs} = I_{bs}/I_p$ is the bootstrap current fraction. $f_{bs}\beta_t$ has been referred to as the sustained β . Progress in this parameter requires either improved plasma shaping or increases in C_T , the Troyon coefficient ($C_T = \beta_{max}aB_t/I_p$). To this end, NSTX is investigating pathways to stronger plasma shaping. Progress to date is reported, including achievement of world record sustained plasma shape factor and world record controlled plasma elongation of ~ 3 . An interesting result of this campaign was the achievement of extremely low sustained normalized internal inductance $l_i \sim 0.3$. The effect of improved plasma shaping on plasma performance as determined by the sustained β will also be presented.

[†]*This work supported by U.S. DoE Contract DE-AC02-76CH0307.*