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Understanding how rotating plasmas can be slowed down

First quantitative agreement between neoclassical toroidal viscosity theory and experiment.

Understanding how plasma rotation can be controlled is an important goal in magnetic fusion research. Scientists from Columbia University, the Princeton Plasma Physics Laboratory, and the University of Wisconsin have performed dedicated experiments in the National Spherical Torus Experiment (NSTX) that slow down plasma rotation in a controlled fashion using magnetic fields, to understand the basic physics of this process. The experiments are shown to quantitatively agree with the theory of neoclassical toroidal viscosity (NTV). [1] This effect can be compared to the force that occurs when fluid flows through a corrugated pipe. The result has specific applicability to stability and momentum transport physics and control in tokamaks, including ITER, and general applicability in understanding plasma momentum transport in magnetic fields (e.g. in space plasmas).

In a tokamak device, NTV is caused by interaction of the plasma with magnetic field components that break the symmetry of the main magnetic confinement field. Unlike the better understood and experimentally verified electromagnetic forces caused by certain plasma instabilities, [2] quantitative agreement between momentum transport in tokamaks and NTV theory has been elusive until now. In the present work, the full NTV theory is computed numerically using reconstructions of the experimental plasma. The experiments examined plasma rotation slowing due to applied fields of different shapes. An accurate 3-dimensional model of the applied field and the inclusion of plasma trapped particle effects are both required to obtain quantitative agreement between theory and experiment. The present results support NTV theory as viable physics for simulations of plasma rotation and torque balance in future tokamak devices.

Results of this work will be presented as part of an invited talk by Dr. S.A. Sabbagh of Columbia University at the APS-DPP meeting in Philadelphia, PA, October 30 to November 3, 2006.*

*Invited paper VI2.00001, "Active Resistive Wall Mode Stabilization in Low Rotation, High Beta NSTX Plasmas"
Invited Session VI2: MHD (Philadelphia Marriott Downtown Grand Salon CDE)
November 2, 2006 (2 PM)
Abstract: http://meetings.aps.org/Meeting/DPP06/Event/53034

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References:
[1] W. Zhu, S.A. Sabbagh, R.E. Bell, et al., *Phys. Rev. Lett.* **96** (2006) 225002.
[2] R. Fitzpatrick, *Nucl. Fusion* **33** (1993) 1049.

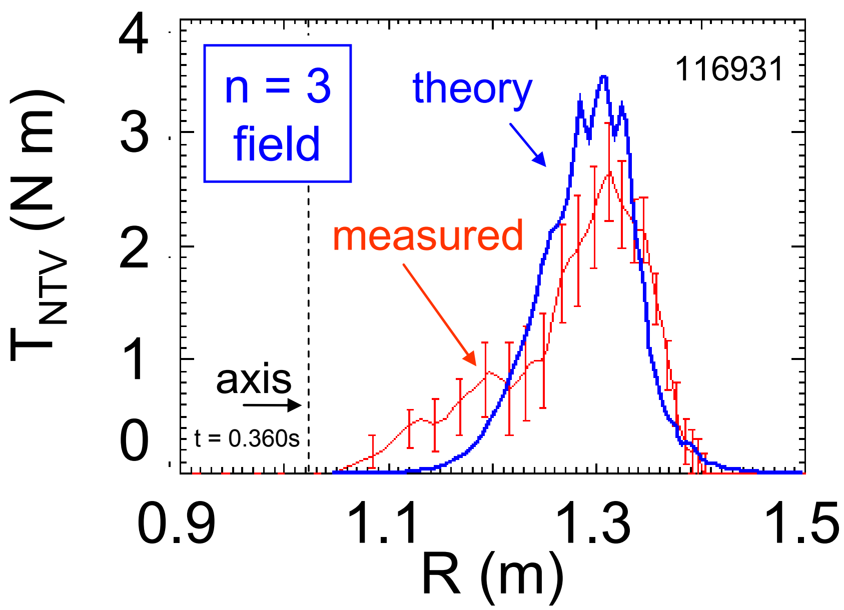

Fig. 1 Comparison of measured experimental $d(I\Omega_p)/dt$ profile to theoretical integrated NTV torque (I is the plasma flux surface moment of inertia and Ω_p is the plasma rotation frequency).