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Peak Neoclassical Toroidal Viscous Force in DIII-D[1]

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A predicted peak in the neoclassical toroidal viscous (NTV) force at ITER-relevant low toroidal plasma rotation has recently been observed [1] in the DIII-D tokamak using its unique capabilities of nearly balanced neutral beam injection and 3D fields applied by internal (I-)coils. The peak was predicted by a theoretical model [1] that smoothly connects the relevant low-collisionality asymptotic NTV regimes [2]. NTV originates from nonambipolar radial particle drifts driven by nonaxisymmetric (NA) magnetic fields that modify the ion parallel stress tensor; it drives the toroidal plasma rotation toward a diamagnetic-type offset flow opposite to the plasma current direction, as observed in DIII-D H-mode plasmas [3]. The maximum NTV force in low collisionality tokamaks occurs where the radial electric field vanishes, and depends critically on the poloidal ion flow [1]; this type of behavior is also applicable to quasi-symmetric stellarators. Using the I-coils to apply a static $n = 3$ magnetic perturbation to an H-mode plasma, the NTV torque as a function of rotation was measured in DIII-D by comparing the beam power required to maintain a preprogrammed toroidal rotation before and after application of the $n = 3$ fields. A localized peak NTV force was observed which is reasonably consistent with neoclassical theory for the damping of poloidal and toroidal flows. NTV has the potential to alter rotation profiles in low external torque configurations for a variety of applications in ITER.

[1] A.J. Cole et al., Report UW-CPTC 10-1 via http://www.cptc.wisc.edu (to be submitted to PRL).
[2] K.C. Shaing et al., Plasma Phys. Control. Fusion **51**, 035009 (2009) and references cited therein.
[3] A.M. Garofalo et al., Phys. Plasmas **16**, 056119 (2009) and references cited therein.

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