Gyrokinetic Simulation of Toroidal Angular Momentum Transport*

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Recent experimental results in C-Mod (J.E. Rice et al.) and DIII-D (J.S. deGrassie et al.) indicate that tokamaks have an intrinsic *source* of toroidal rotation with an inward or *pinched flow*. This has motivated us to carefully re-examination the formulation of toroidal angular momentum and poloidal rotation continuity equations found in Ref. [1]. Our work provides a more explicit formulation for evaluating the turbulent components with the GYRO gyrokinetic code [2] simulations in real tokamak geometry. While GYRO with finite parallel velocity shear providing a Kelvin-Helmholtz drive has been simulating toroidal angular momentum transport since 2003, the radial flow of toroidal angular momentum is now broken into components from the radial-parallel, and radial-perpendicular stress tensors, as well as the convective flow of toroidal angular momentum to better understand the origin of *pinched flows* and how they are affected by ExB velocity shearing. Previous quasilinear estimates in slab geometry treating parallel and ExB shear independently found *pinched flows* possible [3]. Parallel velocity shear and perpendicular ExB shear are of course physically related via radial force balance and the ion pressure gradient profile. Finite parallel velocity (not just sheared parallel velocity) has recently been added to test a possible additional source of pinching in toroidal geometry [4]. Mapping the parametric dependence of core toroidal angular momentum transport and pinch conditions is our key focus. We also use GYRO to evaluate a possible *source* of toroidal angular momentum from the small non-ambipolar component of radial magnetic flutter particle flow. In the core at least, the turbulent viscous transport and source forcing are expected to be small compared to the strong neoclassical magnetic pumping which drags the poloidal rotation to the neoclassical level. However a key point of Ref. 1 is that turbulence can provide some *shift* in the neoclassical poloidal rotation. We use GYRO simulations to determine the size of the shift at finite rho-star.

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[2] http://fusion.gat.com/theory/Gyro.

[3] R.R. Dominguez and G.M. Staebler, Phys. Fluids **B5** (1993) 3876.

[4] A.G. Peeters, C. Angioni, D. Strintzi, "The toroidal momentum pinch velocity," submitted to Phys. Rev. Lett. (2006).

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