Canonical Rotation Profiles from Turbulent Equipartition Theory of Toroidal Momentum Pinch

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The turbulent convective flux (pinch) of the toroidal angular momentum density[1] has been derived using the nonlinear toroidal gyrokinetic equation which conserves phase space density and energy [2], and a novel pinch mechanism which originates from the symmetry breaking due to the magnetic field curvature has been identified. A net parallel momentum transfer from the waves to the ion guiding centers is possible when the fluctuation intensity varies on the flux surface, resulting in imperfect cancellation of the curvature drift contribution to the parallel acceleration. This pinch velocity of the angular momentum density can also be understood as a manifestation of a tendency to homogenize the profile of "magnetically weighted angular momentum density," $nm_iRU_{\|}/B^2$. This part of the pinch flux is mode-independent (whether it's TEM driven or ITG driven), and radially inward for fluctuations peaked at the low-B-field side, with a pinch velocity typically, $V_{Ang}^{TEP} \sim -2F_{Balloon}\chi_\phi/R_0$, where $F_{balloon}$ is a dimensionless quantity between 0 and 1, characterizing the mode structure. At steady state, in the region where torque input is negligible (typically in the core), a definite relation between V_{Ang}^{TEP} and χ_ϕ, from our theory, predicts canonical rotation profiles. We will discuss how these canonical rotation profiles project to ITER, and what's the implication in relation to reduction of turbulence and RWM stabilization. We also compare and contrast the pinch of toroidal angular momentum with the now familiar "turbulent equipartition" (TEP) mechanism for the particle pinch[3] which exhibit some success in various L-mode plasmas in tokamaks, in particular the strong correlation between the canonical n profiles and q profiles.

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