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TH/8-2: A New Paradigm for ExB Velocity Shear Suppression of'Gyro-kinetic Turbulence and the Momentum Pinch

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The toroidal Reynolds stress due to the shear in the ExB velocity Doppler shift acts like a momentum pinch [1] against the parallel velocity shear contribution to the stress. This momentum pinch cannot be computed with the quench rule paradigm [2]. This is because the quench rule only reduces the amplitude of the turbulence and does break the parity of the linear eigenfunctions [1]. Detailed studies of the nonlinear radial wavenumber spectrum of electric potential fluctuations in gyro-kinetic plasma turbulence simulations with GYRO have lead to a new paradigm [3] that is capable of computing the momentum pinch. It is found that shear in the ExB velocity Doppler shift suppresses turbulence by inducing a shift in the peak of the radial wavenumber spectrum and a reduction in the amplitude. An analytic model of the process is used to understand the roles of the sheared velocity and the nonlinear mode coupling. The analytic model leads to a simple formula for the nonlinear spectrum that is used in the quasilinear Trapped Gyro-Landau Fluid (TGLF) model to compute the transport. The TGLF model accurately reproduces the suppression of energy transport and the toroidal Reynolds stress driven by the Doppler shear using the new model fit to the GYRO simulations. The toroidal Reynolds stress is directly due to the finite radial wavenumber of the linear eigenmodes breaking of the mode parity. This new "spectral shift"model is the first to identify the shift in the radial wavenumber spectrum as the central mechanism by which ExB velocity shear suppresses turbulence. Verification of the spectral shift model with GYRO scans over plasma parameters will be presented. Simulation of DIII-D high and low torque discharges using the TGLF model will also be shown.

[1] G.M. Staebler, et al., Phys. Plamas 18 (2011) 056106.
[2] R.E. Waltz, et al., Phys. Plasmas 2, 2408 (1995).
[3] G.M. Staebler, et al., "A new paradigm for the suppression of gyro-kinetic turbulence by velocity shear," submitted to Phys. Rev. Lett. (2012).

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