A new paradigm for $E \times B$ velocity shear suppression of gyro-kinetic turbulence and the momentum pinch

G.M. Staebler[1], J. Candy[1], R.E. Waltz[1], J.E. Kinsey[1], and W.M. Solomon[2]

[1]*General Atomics, PO Box 85608, San Diego, California 92186-5608, USA*
[2]*Princeton Plasma Physics Laboratory, Princeton, New Jersey 08543-0451, USA*
e-mail: Gary.Staebler@gat.com

Abstract. Detailed studies of the nonlinear radial wavenumber spectrum of electric potential fluctuations in gyro-kinetic plasma turbulence simulations have led to a new paradigm that is capable of computing the momentum pinch. It is found that shear in the $E \times B$ 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 that fits the nonlinear spectrum and only depends on the spectral average shift in the radial wavenumber. This "spectral shift" model is the first to identify the shift in the radial wavenumber spectrum as the central mechanism by which $E \times B$ velocity shear suppresses turbulence. Using a quasilinear model of the spectral shift the toroidal Reynolds stress due to the Doppler shear can be computed for the first time. It is shown that, when diamagnetic and neoclassical contributions to the parallel flows are included, the Doppler shear term in the Reynolds stress allows the sign of the intrinsic toroidal rotation to change. Simulation of the co-current and balanced neutral beam injection phase of a DIII-D discharge using the quasilinear model show good agreement with experiment.

PAC Nos.: 52.30.Gz, 52.65.Tt, 52.35.Re, 52.55.Fa