Nonlinear Gyrokinetic Turbulence Simulations of $E \times B$ Shear Quenching of Transport

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Abstract

The effects of $E \times B$ velocity shear have been investigated in nonliner gyrokinetic turbulence simulations with and without kinetic electrons. The impact of $E \times B$ shear stabilization in electrostatic flux-tube simulations is well modeled by a simple quench rule with the turbulent diffusivity scaling like $(1 - \alpha_E \gamma_E/\gamma_{\max})$ where γ_E is the $E \times B$ shear rate, γ_{max} is maximum linear growth rate without $E \times B$ shear, and α_E is a multiplier. The quench rule was originally deduced from adiabatic electron ion temperature gradient (ITG) simulations where it was found that $\alpha_E \approx 1$. We find the quench rule also applies in the presence of kinetic electrons for long wavelength transport down to the ion gyroradius scale. Without parallel velocity shear, the electron and ion transport is quenched near $\gamma_E/\gamma_{\max} \approx 2$ ($\alpha_E \approx 1/2$). When the destabilizing effect of parallel velocity shear is included in the simulations, consistent with purely toroidal rotation, the transport may not be completely quenched by any level of $E \times B$ shear because the Kelvin-Helmholtz drive increases $\gamma_{\max}$ faster than γ_E increases. Both ITG turbulence with added trapped electron drive as well as electron directed and curvature driven trapped electron mode turbulence are considered.

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