Continuum Gyrokinetic Turbulence Simulations with Profile Shear Stabilization and Broken gyroBohm Scaling

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Our newly developed field line following full radius continuum gyrokinetic code (GYRO) recovers standard ITG simulations in a radial annulus with cyclic radial boundary conditions and vanishing radial width ($\Delta r \to 0$): the so called flux-tube limit for vanishing ρ_* (ρ_s/a). We compare these flux-tube results with simulations in a finite Δr radial annulus at finite ρ_* with noncyclic boundary conditions. We experiment with a variety of zero value and zero gradient boundary conditions, with and without buffer boundary layers, to show that without radial profile variation, the flux tube linear instability rates and box average turbulent diffusivities can be reproduced. We term these "benign" boundary conditions. Having isolated or marginalized the effect of non-cyclic boundary conditions, we then can study the effect of radial profile variation within the annulus. We first introduce only linear shear in the equilibrium $E \times B$ velocity comparing the shear rate to the maximum linear growth rate. We then consider a normal full radius profile of temperature and density and $1/r$ cylindrical effects focusing on a Δr annulus at a given $r = r_0$ having the local gradient of the flux tube simulations (*e.g.*, $r_0/a = 1/2$, $R/a = 3.0$, $a/_{LT} = 3.0$, $a/L_n = 1$, $q = 2$, $s = r/q\ dq/dr = 1$). Fixing ρ_*, we first expand the annulus, increasing Δr (and the number of gyroradii in the annulus), showing how the diffusion decreases as more of the profile is sampled (up to some maximum correlation distance): this is the profile stabilzation effect. Secondly, we fix the annulus size Δr, but vary the ρ_* thus breaking the gyroBohm scaling of the flux tube simulations when ρ_* is large enough. Our goal (when the nonadiabatic electrons, finite-beta, and real geometry features of GYRO are included) is to accurately simulate transport in finite radial annuli of an actual DIII–D plasmas.

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