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Coupled ITG/TEM-ETG Gyrokinetic Simulations[1]

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Electron temperature gradient (ETG) transport is conventionally defined as the electron energy transport from high-k where ions are adiabatic and there can be no ion energy or plasma transport. Previous simulations have assumed adiabatic ions (ETG-ai). However using the GYRO gyrokinetic code [1], we have found that many simulation cases with trapped electron at moderate shear do not nonlinearly saturate unless fully kinetic ions and some low-k ion scale zonal flow modes are included. We define high-k ETG-ki transport to be that arising from $k_y\rho_{s-i} > 1$ including electron gyroradius scales $k_y\rho_{s-e} \sim 1$, and ion temperature gradient and trapped electron mode (ITG/TEM) transport to be that from $k_y\rho_{s-i} \leq 1$. There has been speculation [2] that ETG transport could be modified by the nonlinear coupling to the ITG/TEM turbulence (or vise-versa). We have done very expensive high Reynold's number $(k_{\perp-max}/k_{\perp-min})^2 \propto (\rho_{s-i}/\rho_{s-e})^2 = \mu^2$ high-resolution-large-flux-tube simulations with coupled ITG/TEM-ETG-ki turbulence. By comparing expensive simulations with much cheaper uncoupled high-resolution-small-flux-tube ETG-ki and low-resolution-large-flux-tube ITG/TEM simulations, we hope to demonstrate that superposition of the cheaper simulations is sufficiently accurate. Electron energy transport from ETG-ki is 5-10 fold smaller than from ITG/TEM except when the $E \times B$ shear is strong enough to quenched the low-k transport. GYRO compute time for the expensive simulations scales as $\sim \mu^{3-4}$. Reduced mass ratio $\mu = 20$ simulations have been done, and $\mu = 30$ simulations in progress accurately represent the $\mu = 40$-60 physical range.

[1] J. Candy and R.E. Waltz, Phys. Rev. Lett. **91** (2003) 045001.
[2] C. Holland and P.H. Diamond, Phys. Plasmas **11** (2004) 1043.

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