Gyrokinetic Secondary Instability Theory For Electron and Ion Temperature Gradient Driven Turbulence

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Secondary instability theory has proven a useful tool in understanding tokamak turbulence. It has been successfully used to estimate saturation amplitudes, predict the spectrum in simulations of fully developed tokamak turbulence and help understand the observed breakdown of "isomorphism" between ITG and ETG turbulence (Jenko, Dorland, Phys. Rev. Lett., Vol. 89, No. 22). This work presents a fully gyrokinetic secondary instability theory. The local kinetic dispersion relation is solved to generate a primary mode. The secondary mode is a small perturbation to the primary mode and satisfies an integral equation with a periodic kernel. Finite Larmor radius (FLR) and other kinetic effects are treated exactly capturing $k\rho > 1$ as well as $k\rho \ll 1$ quasi-singular behavior. It is therefore well suited to describe the intermediate regime of ITG/ETG coupling. The secondary instability of toroidal ($k_\parallel = 0$) and slab ($L_T/R = 0$) primary modes are computed along with spectral characteristics and parametric dependence. The convergence properties of the computation of the secondary instability of ETG toroidal modes underscores the need for proper k-space resolution in simulations. Parametric dependence of secondary mode growth rate suggests a mechanism for enhanced transport suppression.