Damped Mode Contributions to Electromagnetic ITG Stabilization

G.G. Whelan, M.J. Pueschel, P.W. Terry

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Electromagnetic effects strongly reduce ITG-driven turbulent transport beyond the partial stabilization of the linear growth rate. Tracking nonlinear energy transfer has revealed that linearly unstable ITG saturates primarily through nonlinear energy transfer to stable modes catalyzed by zonal flows. A key component of this description is that stable modes exist at every wavenumber unlike homogeneous Navier-Stokes turbulence where the damping occurs only at small scales. We analyze the changes to the turbulence through a β scan using Gene simulations to determine why transport is significantly reduced by magnetic fluctuations.

Simple mixing-length quasilinear transport models predict that transport scales with growth rate, which alone cannot explain the magnitude of nonlinear electromagnetic stabilization. There are multiple other contributors which explain most of the transport reduction: The effective growth rate, defined as linear energy production normalized by energy, decreases more with β than the linear growth rate, because of dissipation by damped modes. Heat flux normalized by energy decreases with β, because damped modes collectively contribute a pinch effect which grows stronger. These effects work in tandem with an increased efficiency of the zonal flow catalyzed energy transfer. We examine possible causes of these effects such as changes to linear mode stucture affecting nonlinear coupling and triplet correlation lifetimes.