Multi-Scale Simulations of ITG and ETG with Sheared Flows

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Quasi-two-dimensional pseudo-spectral simulations of ITG-ETG-sheared flow turbulence are presented from model equations with hyperviscosities. Probability distributions functions (PDF) of the vorticity $\omega = \rho^2\nabla^2\phi$ and the filtered vorticity $\zeta = (1-\rho^2\nabla^2)\rho^2\nabla^2 = \sum_1^\infty \rho^{2n}\nabla^{2n}\phi$ are presented for grids up to $(1024)^2$. The PDFs are characterized by heavy tailed PDFs rather than gaussians. We study the turbulence power transfer between wavenumber bands $[k_n, k_{n+1}]$ from restricted sums of $P_n = \sum \boldsymbol{k}_1 \times \boldsymbol{k}_2 \cdot \hat{\boldsymbol{z}}(k_2^2 - k_1^2)\phi_{k_1}\phi_{k_2}\phi_{k_3}$ where the conservation of energy follows from the $\Sigma P_n = 0$. From characterizations of P_n, low-order models of the interaction of $W_{\rm ITG}$, $W_{\rm ETG}$ and F-shear flow are constructed.

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