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Multi-Scale Temperature Gradient Driven Turbulence in Tokamaks

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Transport in tokamaks with high-power auxiliary is predicted to occur through a mixture of mesoscale ion temperature gradient (ITG) turbulence and microscale electron temperature gradient turbulence (ETG). Renormalized turbulence theory gives an analytic method of studying correlation lengths and spectra in the bi-modal system within the limits of near-gaussian statistics in a stationary state of turbulence. To include coherent structures and intermittency, direct numerical simulations (DNS) are required on large grids. For this purpose, synthesized toroidal ITG-ETG models suitable for $(1024)^2$ pseudo-spectral simulations are examined with four dynamical pdes and several constraint equations. The system parameters are $R/L_{T_i}, R/L_{T_e}, T_e/T_i, m_i/m_e$ and ω_{pe}/ω_{ce}. For $(m_i/m_e)^{1/2} = 40$ the box size $(20\pi\rho_i)^2$ resolves scales down to λ_{De} and ρ_e. The inverse cascades, the formation of streamers and vortices and the cross-scale coupling of γ_i, W_i, q_i and γ_e, W_e, q_e are then objects of comparison between the DNS and turbulence theory.

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