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Scaling Theory for Energy Distribution in Dissipated Mode Space

P.W. TERRY, University of Wisconsin-Madison, D.R. HATCH, IPP, Garching, J.-H. KIM, University of Wisconsin-Madison — Recent gyrokinetic simulations reveal that ITG turbulence excites a large number of damped modes in the perpendicular wavenumber range of the instability. In this wavenumber range, these dissipative structures achieve equipartition of amplitude attenuation rate across the modes of a proper orthogonal decomposition (POD). Equipartition is equivalent to a scaling theory in mode space, with a power law energy distribution having POD damping rate as the scaling variable. This surprising manifestation of symmetry in a non-inertial turbulent energy transfer range is rooted in mode coupling. Energy from unstable modes is directly and simultaneously transferred to all damped modes in a parallel fashion, enabling a scaling theory even in a dissipation range. In contrast, the hydrodynamic cascade couples modes serially, requiring zero dissipation to achieve scaling and power law behavior. A mode coupling theory shows that all modes are in a dissipative balance, but that the few hundred modes with weakest damping, spill some energy into a wavenumber cascade to small perpendicular scale.

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