

Collisionless zonal flow saturation via symmetric dynamics

A.A. Azelis and P.W. Terry

Department of Physics, University of Wisconsin-Madison,
Madison, WI 53706

In ion temperature gradient (ITG) driven turbulence, the manner in which zonal flows saturate in the absence of collisionality remains an outstanding question. In this work, collisionless zonal flow saturation is analytically investigated using a reduced two field fluid model for ITG driven turbulence subject to a 3-wavevector, 5-mode truncation. Using weak turbulence closure theory, a wave kinetic equation is derived describing how the zonal flow energy spectrum for this system will fluctuate with time according to linear and nonlinear dynamics. The terms in the nonlinear time evolution operator, which describe resonant energy transfer among triads of fluctuations, are expressed as matrices whose elements are arithmetic combinations of the linear eigenvalues of the individual modes participating in a given interaction. In the collisionless limit, the matrices characterizing zonal flow-drive and damping become highly symmetric, and conditions are found for spectral saturation in this regime. One set of such stationary solutions to the wave kinetic equation suggests a state of turbulent fluid in which down- and up-gradient thermal energy transport (from stable and unstable modes, respectively) at each fluctuation length scale are perfectly balanced. A change of variables characterizing the proximity of the ITG system to a state of "balanced-transport" is then proposed as an alternative to explicit energetic descriptions of the turbulence. Generalization to the non-truncated system is briefly discussed.

This work was supported by the US DOE grant DE-FG02-89ER53291.