

Testing Our Understanding of Nonlinear Drift Turbulence Dynamics Using Simple Laboratory Plasmas G.R. Tynan, P.H. Diamond, O.D. Gurcan, C. Holland, S.H. Muller, M. Xu, Z. Yan, J. Yu
University of California San Diego

We present key results from a series of experiments carried out on the CSDX linear plasma device at UCSD designed to study the nonlinear dynamics of drift turbulence and zonal flows in confined plasmas. These plasmas exhibit coherent collisional drift waves above a critical magnetic field, which then transition to a state of weak turbulence characterized by the nonlinear interaction of a significant number of nonlinearly interacting drift waves which nearly satisfy the linear dispersion relation. The evolution of the energy spectrum during this transition shows net transfer of energy to the largest azimuthal scales in the system, and measurements of the turbulent Reynolds stress are consistent with an azimuthally symmetric shear layer which is observed in the turbulent state, indicating that the shear layer is related to the radial transport of angular momentum. Detailed studies of the shear layer and Reynolds stress using a combination of fast imaging of fluctuations and probe arrays show that both are modulated on a slow time scale ($\sim 0.01\text{-}0.03 \omega^*$), and that this modulation also governs the amplitude of the higher wavenumber turbulent fluctuations. Multi-tip based cross-bispectra estimates show the frequency-domain decomposition of the nonlinear energy transfer, allowing identification of both the unstable drift waves and nonlinearly driven, linearly damped modes, while fast imaging also allows the direct study of flow-shear decorrelation of turbulent structures within the plasma. A comparison with new theoretical results suggests a strong relationship between the turbulent Reynolds stress and the transport of mean vorticity. These results show how suitably designed laboratory plasma experiments can be used to provide fundamental tests of theory, validate collisional fluid simulations, and provide deeper insight into the key nonlinear dynamics of drift turbulence and zonal flows in magnetized confined plasmas.