Testing and Validating Nonlinear Gyrokinetic Turbulence Predictions via Multi-Field Turbulence Profile Measurements*

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Testing and validating the predictions of turbulence-based transport simulations is critical for extrapolation to next-step fusion devices. Such detailed comparison is not straightforward, and can reveal both measurement and theoretical limitations while also motivating future improvements in experiments. In the present work, simultaneous measurement of the profiles of two turbulent fields (density and electron temperature) has been used to test predictions obtained from a nonlinear gyrokinetic code (GYRO). The spatially resolved turbulence *profiles* of *two* parameters provide a severe constraint. The turbulent electron temperature and density fluctuation measurements were performed in DIII-D neutral beam heated L-mode plasmas. The rms amplitude and spectra of the electron temperature fluctuations are measured at multiple radial locations using the technique of correlation electron cyclotron emission (CECE) radiometry. The UCLA CECE diagnostic has sub-centimeter radial resolution and through the use of Gaussian optics a poloidal spot size with w_0~1.75cm. This allows turbulent wavenumbers < 1.8 cm^{-1} to be resolved. Local density fluctuations are measured with Beam Emission Spectroscopy. In these neutral beam heated L-mode plasmas, core electron temperature fluctuations in the region $0.5 < r/a < 0.9$ increase with radius from ~0.5% to ~ 2%, similar to simultaneously measured density fluctuations. After incorporating "synthetic diagnostics" to effectively filter the code output, the simulations reproduce the characteristics of the turbulence and transport at one radial location r/a = 0.5, but not at a second location, r/a= 0.75. Potential reasons for this disagreement are explored. Future experiments and simulations that focus on identifying robust quantities for testing and validation are discussed.

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