Measurements of the Cross-Phase Angle Between Density and Electron Temperature Fluctuations and Comparison with Gyrokinetic Simulations

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Abstract. This paper presents new measurements of the cross-phase angle, $\alpha_{n_e T_e}$. between long-wavelength ($k_\theta \rho_s < 0.5$) density, $\tilde{n}_e$, and electron temperature, $\tilde{T}_e$, fluctuations in the core of DIII-D [J.L. Luxon, Nucl. Fusion **42**, 614 (2002)] tokamak plasmas. The coherency and cross-phase angle between $\tilde{n}_e$ and $\tilde{T}_e$ are measured using coupled reflectometer and correlation electron cyclotron emission (CECE) diagnostics that view the same plasma volume. In addition to the experimental results, two sets of local, nonlinear gyrokinetic turbulence simulations that are performed with the GYRO code [J. Candy and R.E. Waltz, J. Comput. Phys. **186**, 545 (2003)] are described. One set, called the pre-experiment simulations, was performed prior to the experiment in order to predict a change in $\alpha_{n_e T_e}$ given experimentally realizable increases in the electron temperature, T_e. In the experiment the cross-phase angle was measured at three radial locations (ρ=0.55, 0.65 and 0.75) in both a "Base" case and a "High T_e" case. The measured cross-phase angle is in good qualitative agreement with the pre-experiment simulations, which predicted that $\tilde{n}_e$ and $\tilde{T}_e$ would be out of phase. The pre-experiment simulations also predicted a decrease in cross-phase angle as T_e is increased. Experimentally, this trend is observed at the inner two radial locations only. The second set of simulations, the post-experiment simulations, is carried out using local parameters taken from measured experimental profiles as input to GYRO. These post-experiment simulation results are in good quantitative agreement with the measured cross-phase angle, despite disagreements with transport fluxes. Directions for future modeling and experimental work are discussed.