Validation of ion-scale gyrokinetic simulations against measurements of turbulence amplitude and structure

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An experimental understanding of turbulent fluctuations in tokamak plasmas is necessary for providing confidence in the extrapolation of heat transport models to future experimental devices and reactors. Guided by predictions from nonlinear gyrokinetic simulations, two new turbulence diagnostics were designed and installed at ASDEX Upgrade (AUG) to probe the fundamentals of ion-scale turbulent electron heat transport.

The first, a 30-channel correlation ECE (CECE) radiometer (105-128 GHz, 2nd harmonic X-mode), introduces a novel channel comb arrangement [1]. This allows measurements of high radial resolution profiles ($0.5 < r/a < 0.8$) of low-k ($k_\theta \rho_s < 0.3$) temperature fluctuation amplitudes, δT_e, frequency spectra and radial correlation length, $L_r(T_e)$, profiles in unprecedented detail. The second diagnostic is formed by the addition of a W-band X-mode reflectometer on the same line of sight to enable measurements of the phase angle between turbulent density and temperature fluctuations (α_{nT}). Previously the radial alignment between reflectometer and radiometer has been a challenge due to the requirement that alignment is achieved within a radial correlation length (< 5-10 mm). This challenge is significantly alleviated by using the CECE channel comb arrangement and the maximal coherence between reflectometer and radiometer can be unambiguously captured.

Measurements of these quantities have been made in an AUG L-mode plasma, at the same radial location and have provided simultaneous *quantitative* constraints on realistic gyrokinetic simulations using the gyrokinetic code GENE [2]. A gyrokinetic sensitivity scan is performed by varying the input gradients (∇T_i, ∇T_e) within their experimental uncertainties. A combined metric [3] is used for the first time to quantify the level of agreement between simulation and experiment. Simultaneous quantitative agreement is found for electron and ion heat flux, α_{nT} and $L_r(T_e)$, whereas δT_e is found to be higher in simulations compared to the experiment.

References

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