Turbulence in ASDEX Upgrade: Can gyrokinetic simulations match the fluctuation measurements?

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One of the goals of fusion research today is to perform first-principle simulations and make quantitatively accurate predictions of experimentally measured quantities over a broad range of plasma conditions.

An important and necessary step toward the achievement of this goal is to demonstrate that the gyrokinetic codes are able to reproduce all of the turbulence features found in current devices. This so-called validation process has led to quantitative comparisons between experimental data and results of gyrokinetic simulations by comparing simultaneously several quantities. In this regard, the improvement of fluctuation diagnostics, which allows measurements of the turbulence features, such as density and temperature fluctuations, wavenumber spectra, and even cross-phases between different quantities with high precision, has been indispensable for the validation process.

We will describe a recent step in this direction by presenting simulation results with the gyrokinetic code GENE for an ASDEX Upgrade discharge. In particular, after flux-matched simulations are achieved, density fluctuations measured by means of Doppler reflectometry are compared with results of gyrokinetic simulations [1,2]. We will also show that density and temperature fluctuation amplitudes and even the fluctuation spectra can be very sensitive to small changes in the profile gradients. This implies that a match of gyrokinetic simulations with experimental measurements for these quantities can be very difficult to achieve. However, it is observed that cross-phases between different quantities are robust to changes in this parameter, indicating that cross-phases could be a better observable for comparisons with experimental measurements. Finally, we will address recent developments and unsolved issues in validating gyrokinetic turbulence models.