US/EU TTF – Sevilla, September 2018

Juan Ruiz Ruiz

Title

Validation of novel hybrid scale ETG simulations in NSTX via comparisons of simulated turbulence with a new high-k scattering synthetic diagnostic.

Abstract

Despite much research since the discovery of ETG (Electron Temperature Gradient) turbulence, open questions remain regarding the impact of ETG on the electron thermal transport observed in spherical tokamak plasmas. A rigorous, first-of-its-kind, validation study of ETG turbulence in an NBI heated NSTX H-mode has been performed using nonlinear gyrokinetic simulations with a new high-k scattering synthetic diagnostic. In conditions of low ETG drive, hybrid scale simulations match experimental heat fluxes, but not in high ETG drive cases. Also, this work shows for the first time that measured frequency spectra of ETG fluctuations is not a critical constraint on simulation, in contrast to past work [Ethier, Ernst]. Novel hybrid-scale simulations (GYRO) capture both ion and electron scale modes, with minimum $k_\theta \rho_s = 0.3$ and maxima beyond the peak of the linear ETG growth rate. In the low ETG drive case, hybrid scale simulations can match the experimental heat flux (Q_e) within uncertainty, but e-scale simulations underpredict Q_e. In the strongly driven ETG case, ion scale modes are shown to be stabilized by ExB shear, and both hybrid and e- scale simulations underpredict Q_e. To quantitatively compare the measured frequency and wavenumber spectra of high-k fluctuations, a new real-space implementation of the synthetic high-k scattering diagnostic has been developed. Comparisons with measured turbulence reveal that when Q_e is underpredicted in simulation, it is still possible to reproduce the frequency spectral shape (mean frequency and width). But the changes in the fluctuation levels between the two cases and the shape of the high-k wavenumber spectra disagree with experiment. The comparison with heat fluxes also indicates that ion scale dynamics, and possibly cross-scale coupling, might be needed to account for electron thermal transport in these H-modes. [Ethier IAEA 2010, Ernst POP 2016]. Work supported by U.S. DOE contracts DE-AC02-09CH11466 and DE-AC02-05CH11231.