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Comparison of Measurements of Profile Stiffness in HSX to Nonlinear Gyrokinetic Calculations

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Tokamaks and stellarators have observed significant differences in profile stiffness, defined as the ratio of the transient thermal diffusivity obtained from heat pulse propagation to the diffusivity obtained from steady-state power balance. Typically, stellarators have measured stiffness values below 2 and tokamaks have observed stiffness greater than 4. In this paper we present the first results on stiffness measurements in the quasihelically symmetric experiment HSX in which the neoclassical transport is comparable to that in a tokamak and turbulent transport dominates throughout the plasma. Electron Cyclotron Emission (ECE) is used to measure the local electron temperature perturbation from modulating the ECRH system on HSX. Spectral analysis of the ECE data yields a profile of the perturbed amplitude and a resulting transient electron thermal diffusivity that is close to the steady-state diffusivity. This evidence of a lack of stiffness in HSX agrees with the scaling of the steady-state heat flux with temperature gradient. The experimental data is compared to gyrokinetic calculations using the GENE code with two kinetic species. Linear calculations demonstrate that the Trapped Electron Mode (TEM) is the dominant long-wavelength microturbulence instability with growth rates that scale linearly with electron temperature gradient. Nonlinear gyrokinetic flux tube simulations indicate that the TEM contributes significantly to the saturated heat fluxes in HSX, shifting the transport-carrying wavenumbers to larger values than in typical Ion Temperature Gradient (ITG) turbulence. A set of nonlinear simulations are being executed, examining the saturated nonlinear heat flux as a function of the electron temperature gradient, to obtain a stiffness value from the simulations to compare with experimental results.
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