# Nonlinear gyrokinetic simulation of long wavelength microturbulence in HSX

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Nonlinear, gyrokinetic, flux tube simulations of Helically Symmetric eXperiment (HSX) plasmas are presented. Two-species linear and nonlinear simulations show that the Trapped Electron Mode (TEM) is the dominant linear and nonlinear microturbulence mode for plasmas with parameters similar to experimental HSX parameters ($T_e > T_i$, $\nabla T_i \approx 0$) [1,2]. Nonlinear simulations show the development of zonal flows that may serve as the saturation mechanism for the TEM. HSX has small averaged magnetic shear with $|\hat{s}| \leq 0.1$ for $r/a < 0.9$, where $a$ is the plasma minor radius. This low shear requirement complicates flux tube simulations, as the minimum numerical box size in the radial direction is set by $l_x = 1/(\hat{s}\ k_y^{\min})$ and a reasonable choice of $k_y^{\min}\rho_s = 0.1$ leads to $l_x$ **~ 222**$\boldsymbol{\rho_s}$ for a flux tube on the half toroidal flux surface. Gyrokinetic simulations indicate that the low shear has a significant influence on the physics of the longest wavelength modes, where $k_y\rho_s < 0.2$ and ion scale turbulence is usually dominant. Linear simulations show the emergence of a large scale, slab-like mode as the density gradient is increased. While the linear growth rate of these modes is small compared to the peak TEM growth rate at $k_y\rho_s = 2.1$, nonlinear simulations show the mode eventually dominates the nonlinear transport as the density gradient is increased. In particular, the growth of the mode leads to the destruction of the zonal flows and subsequently increases transport. However, the physics of the long wavelength mode is sensitive to choice of flux tube within the same flux surface.

**References**

[1] Faber, B.J. *et al.* “Gyrokinetic studies of trapped-electron mode turbulence in HSX.” *In preparation.*

[2] Weir, G.M. e*t al.* “Comparison of Measurements of Profile Stiffness in HSX to Nonlinear Gyrokinetic Calculations.” Invited talk at APS-DPP 2015.