Phase contrast imaging of turbulent density fluctuations in Wendelstein 7-X

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The Wendelstein 7-X stellarator (W7-X) is optimized to reduce neoclassical transport. Thus, turbulent transport is expected to play a significant role in the regulation of particle and heat fluxes. Numerical simulations in the full W7-X magnetic field geometry indicate a range of instabilities from electron (trapped electron and electron temperature gradient modes, TEM and ETG) to ion scales (ion temperature gradient modes, ITG) that can contribute to turbulent transport. Their growth rates at different radii are sensitive to the local gradients in plasma parameters (electron and ion temperature, density), collisionality, ion mass as well as the specific (externally imposed) magnetic configuration. Full flux surface simulations also show a localization of fluctuations both toroidally and poloidally, contrary to the toroidally symmetrical outboard localization observed in Tokamaks.

W7-X has recently completed its second operation phase, the first in full divertor geometry. Throughout the campaign, a wide range of electron cyclotron heating and fueling scenarios have been tested, including pellet injection and possible divertor detachment in a range of different magnetic configurations. Of specific interest to turbulence characterization are matched discharges across different magnetic configurations. TEMs have been shown analytically to be suppressed in quasiisodynamic configurations (which W7-X can come close to), while ITG simulations show increased activity at high elongation. Turbulence diagnostics at W7-X include reflectometers, correlation ECE systems and the recently completed phase contrast imaging (PCI) system that measures poloidally resolved electron density fluctuations along a sight line through the plasma center. The project is a collaboration between the MIT PSFC and IPP.

This contribution aims to identify characteristic features of density fluctuations in W7-X across its wide range of operating scenarios in both frequency and poloidal k-space, taking advantage of the 32 poloidal measurement channels that cover a large wavenumber range from 0.5-23 cm^{-1}. In particular, the existence and modification of density gradient driven TEMs and ion temperature gradient driven ITGs under changes to both the magnetic configuration and plasma profiles will be investigated.