Edge plasma density fluctuations in enhanced confinement phases of pellet experiments in the Wendelstein 7-X stellarator

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In the latest experimental campaign of Wendelstein 7-X hydrogen pellets were utilized for core plasma fuelling. In some of these experiments, unexpected increase of ion temperature was observed after a series of pellet injections, accompanied by the drop of core density fluctuation level, which was measured by the PCI diagnostic **[1]**. These transient periods were extensively studied by both experiments and modelling. The primary candidate for the explanation is that the ITG turbulence is reduced by the steeper density gradient, which is built by the pellet fuelling. Although, according to the modelling, the turbulence suppression occurs in the core, considerable changes are also observed in the edge plasma region, which will be presented in this paper.

An alkali Beam Emission Spectroscopy (BES) diagnostic is operated at W7-X from 2016, which is capable of the measurement of both the edge plasma density profile, and its fluctuations. The 40 channel BES system utilizes state of the art detector technology and optics solutions, which results 5mm radial and 0.5 μs temporal resolution. Due to the applied advanced beam modulation techniques background corrected density profiles can be reconstructed with up to 100 kHz frequency. The beam atoms are gradually ionized as they penetrate the plasma which, depending on plasma density, limits the observation range to the outer ~10-15cm.

In the analysis of the BES data four characteristic time intervals were identified as the discharge evolves, which includes the post pellet phase, the enhanced confinement time range, the confinement degradation phase and the steady state conditions. The relative fluctuation amplitude profiles, the power spectra and correlation functions are analyzed in these intervals and are compared. The relative fluctuation amplitude drops in the enhanced confinement regime and grows significantly as the confinement degrades. In this phase the power density spectrum shows sudden increase in 1-10kHz frequency range and the correlation analysis reveals an increase of the radial correlation length of the turbulent structures. Cross-correlation analysis of radially displaced channels unfolds radial propagation.

[1] A.v. Stechow et al. „Suppression of core turbulence by profile shaping in Wendelstein 7-X“, arXiv:2010.02160 [physics.plasm-ph]

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