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Overview of plasma turbulence structure studies in the ASDEX Upgrade tokamak

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Plasma turbulence plays a crucial role in the performance of future fusion devices. Prediction of confinement in next step machines remains the primary challenge for transport models and first principle codes, which need to be validated against experiment. To this end, an extended set of fluctuation measurements was developed on ASDEX Upgrade using various microwave techniques (radial correlation Doppler reflectometry, poloidal correlation reflectometry, ultra-fast sweep reflectometry, correlation ECE). Together with new analysis techniques and synthetic diagnostics [1,2], which proved to be essential for accurate comparison, they provide a broad variety of turbulence characteristics which are key elements in setting the turbulent transport rate: typical eddy sizes [2,3] and their scaling [3], wavenumber spectra [1] which result from the nonlinear interactions between scales, decorrelation rates [4], eddy asymmetry and eddy tilting [5], n-T cross-phase [2]. Combined with detailed transport studies and gyrokinetic calculations, eddy tilt angle and fluctuation phase velocity proved to be a marker of the transition from dominant ion to electron heat transport regime [5,6]. Furthermore, the comparison between hydrogen and deuterium plasma with matched kinetic profiles and energy content provides a natural framework to study turbulence scales. Fluctuation correlation lengths are found to scale with the ion Larmor radius at short distance consistently with gyro-Bohm models. However, a deviation from gyro-Bohm characteristics is observed in the form of a secondary, longer, radial correlation length [2,3] that could be a signature of an avalanche like transport behaviour [7], and could result in the observed stronger confinement degradation with increased power coupled to ions. This would be the dominant mechanism to explain the confinement degradation from D to H, when larger power goes to ions due to the larger energy exchange between electrons and ions. When the latter is matched, there is no degradation [8].

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