Pedestal instabilities during the L-H transition

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Introduction

High confinement regime (H-mode) [1] is a foreseen experimental condition for plasma fusion device as it provides the best confinement performances. On the other hand, the effects of deleterious ELM events on plasma facing components during this improved performance is a strong concern for future nuclear reactors. Since the discovery of the H-mode in ASDEX-Upgrade tokamak plasmas [2] the L-H transition is still an active subject of research. This transition occurs in a narrow region close to the edge and is characterized by a transport barrier, which leads to a steep pedestal pressure next to the separatrix in the confined plasma. In order to improve the overall knowledge of this transition we have used an ultra-fast continuous frequency swept reflectometry, which provides a high spatio-temporal resolution analysis of density, gradients and turbulence [3]. This work aims to characterize the evolution of the instabilities continuously from the I-phase generation to the ELM crashes.

Diagnostic

Measurements were performed using V and W band X-mode reflectometry diagnostics installed on AUG. They can be frequency swept in 1 µs with a dead time as short as 0.25 µs in between sweeps which provides a sampling rate of 800 kHz. It allows the determination of the density and fluctuation profiles at the same time. While one sweep help to calculate a density profile, fixed frequency signals from sweep to sweep allows, as hoping system, to provide about 2000 probing frequency steps. The density fluctuations are determined from the analysis of the signal phase [4] as

$$\delta n/n \sim \sqrt{\nabla N_X^2}.\boldsymbol{\delta\Phi_{rms}}$$

where the phase fluctuations are calculated from the power spectrum $P_{\delta\Phi}(\omega) = \left|FFT\left(e^{i\delta\Phi(t)}\right)\right|^2$ where according the Parseval theorem $\delta\Phi_{rms} = \sqrt{\int P_{\delta\Phi}(\omega)\, d\omega}$ thus allowing a frequency selection of the turbulence.

L-H transition

The edge transport barrier is the result of local and poloidaly rotating flow induced by a radial electric field (whose origin is still not yet fully understood). This transition is accompanied by a reduction of the turbulence [5] due to a strong E_rxB shear flow with the formation of a steep pedestal at the plasma edge because of an increase of the edge pressure gradient, which in turn