Edge instabilities across the L-H transition and in H-mode of ASDEX Upgrade

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The H-mode is currently the preferable operational regime for a fusion reactor but the physics of the L-H transition and confinement enhancement is not yet fully understood. Turbulence suppression is responsible for the formation of the edge pedestal, whose growth is believed to be limited by the onset of instabilities. The L-H transition in ASDEX Upgrade (AUG) is often accompanied by the appearance of edge coherent [1] or quasi-coherent modes (QCMs) [2] in density fluctuations. QCMs have also been detected in other devices [e.g. 3-4], including during ELM cycles. The underlying instabilities of these modes are mostly an open question, despite their relevance for understanding edge transport and pedestal physics.

Slow power ramp shots at different densities have been conducted in AUG to study edge instabilities across the L-H transition and in H-mode, including the intermediate I-phase. Reflectometers are the main diagnostics used in this work, with emphasis on the frequency modulated continuous wave reflectometer, which has the unique capability of providing simultaneous measurements on the high-field side (HFS) and low-field side (LFS). It was operated either in fixed frequency to measure density fluctuations at several radial positions or in broadband sweeping mode to measure density profiles.

The existence of edge coherent and quasi-coherent modes with frequencies ranging from ~40 to 140 kHz and a complex time evolution after the L-H transition is observed. Their type and behavior is different for the low and high density branches of the L-H power threshold. At low density, the modes are coherent and have an up-chirping frequency with a multi-peak structure. They are observed at the LFS and HFS and also feature a radial magnetic field component, with dominant toroidal mode numbers from -3 to -9, where the negative sign indicates propagation in the electron diamagnetic direction in the lab frame. In the high density shots, the mode is quasi-coherent, with a down-chirping frequency and a broad peak structure. It is observed in the density fluctuations but does not appear in the magnetic coil signals. At medium density, near the minimum L-H power threshold, both types of modes are observed: first the one with magnetic component and then the one without. There is a period of alternation between the two types, which suggests different instabilities come into play. These modes may play an important role in the H-mode pedestal structure, stability and confinement. Their characteristics and relation to the inter-ELM modes will be discussed.

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[4] A. Diallo et al, NF 55, 053003 (2015)

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