EDA H-mode in ASDEX Upgrade

L. Gil[1], C. Silva[1], T. Happel[2], G.D. Conway[2], P. David[2], R. Dux[2], A. Kallenbach[2], T. Pütterich[2], J. Santos[1], A. Silva[1], U. Stroth[2,3], E. Wolfrum[2], the ASDEX Upgrade Team* and the EUROfusion MST1 Team†

[1] *Instituto de Plasmas e Fusão Nuclear, Instituto Superior Técnico, Universidade Lisboa, PT*
[2] *Max-Planck-Institut für Plasmaphysik, Boltzmannstr. 2, 85748 Garching, Germany*
[3] *Physik-Department E28, Technische Universität München, 85748 Garching, Germany*

The H-mode is usually regarded as the preferable operation regime for a fusion reactor due to its superior confinement properties, but it comes with a major disadvantage: edge-localized modes (ELMs), which lead to unacceptably high heat loads on the divertor plates when extrapolated to large-scale machines. Even though a few steady-state ELM-free modes of operation are known [1], each of them has different drawbacks and the ideal solution has not yet been identified. Therefore the discovery, study and development of alternative regimes is very important for the success of fusion energy.

This presentation reports on a stationary H-mode without ELMs achieved in ASDEX Upgrade (AUG) by applying central electron cyclotron resonance heating with adequate fueling in favorable ∇B configuration [2]. This regime is identified as the EDA H-mode and exhibits several desirable features for future reactors, such as dominant electron heating, low input torque, possibility of access at low input power and directly from L-mode, good energy confinement, with an enhancement factor $H_{98y2} \approx 0.9$-1.3, high density, with a Greenwald fraction $f_{GW} \approx 0.8$-0.9, and no impurity accumulation despite the absence of ELMs.

The EDA H-mode in AUG always features an edge electromagnetic quasi-coherent mode (QCM) whose density fluctuations are measured by several diagnostics. The QCM seems to be responsible for enhanced transport losses as its appearance and disappearance are correlated with changes in edge and divertor parameters. This regime shares several features with Alcator C-Mod's EDA H-mode [3], for example being obtained with significant electromagnetic wave heating, becoming more robust at high triangularity, not existing with too low fueling and featuring an edge QCM which produces outward plasma transport, enabling steady-state operation with good confinement and no ELMs.

To qualify as a reactor operating scenario, an ELM-free regime must be integrated with core and divertor radiative cooling. Experiments at AUG with argon seeding [4] showed the compatibility of radiative cooling with no ELMs up to almost 8 MW so far, including neutral beam injection. This contribution will present the main properties and recent results of experiments on the EDA H-mode in AUG, which is a promising regime for future devices such as ITER and DEMO.

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* See the author list of H. Meyer et al. 2019 Nucl. Fusion 59 112014
† See the author list of B. Labit et al. 2019 Nucl. Fusion 59 0860020