EDA H-mode in ASDEX Upgrade: a promising ELM-free regime

L. Gil[1], G.D. Conway[2], P. David[2], R. Dux[2], M. Faitsch[2], T. Happel[2], A. Kallenbach[2], T. Pütterich[2], J. Santos[1], A. Silva[1], C. Silva[1], J. Stober[2], 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 de Lisboa, Portugal
[2] Max-Planck-Institut für Plasmaphysik, Boltzmannstr. 2, 85748 Garching, Germany
[3] Physik-Department E28, Technische Universität München, 85748 Garching, Germany

e-mail (speaker): lgil@ipfn.tecnico.ulisboa.pt

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 several ELM-free scenarios are known [1, 2], 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) with significant electron cyclotron resonance heating [3]. It is obtained in favorable ∇B configuration via adequate fueling and heating power above the L-H transition, but below the ELM threshold. The regime is identified as the EDA H-mode [4, 5] and its ability to maintain a steady-state pedestal without ELMs is likely due to benign edge instabilities, including a ubiquitous electromagnetic quasi-coherent mode that appears to drive enhanced transport.

Different measures have been taken to improve the performance of the EDA H-mode in AUG, which now features numerous desirable properties for future reactors. These include good energy confinement, with an enhancement factor $H_{98y2} \approx 0.9\text{-}1.3$, high density, with a Greenwald fraction $f_{GW} \approx 0.8\text{-}1.0$, low impurity content, compatibility with tungsten walls, possibility of access at low input torque and power, with dominant electron heating, no need for a fresh boronization, and no impurity accumulation despite the absence of ELMs. Furthermore, nitrogen seeding in EDA H-mode proved very effective in reducing divertor heat fluxes, and argon seeding [6] showed the compatibility of pedestal radiative cooling with no ELMs at high heating power, so far up to $P_{tot} \approx 11$ MW and $\beta_N \approx 2.4$, including considerable 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.

References

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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 086020