H-mode power threshold experiments in mixed ion species plasmas on TCV

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For ITER operation in the high confinement mode (H-mode) it is important to understand the dependence of the H-mode power threshold, P_{L-H}, on the main ion composition. Not only will fusion operation be performed in mixed deuterium-tritium (D-T) plasmas, but also the pre-fusion power operation will be performed in helium (He) or, preferentially, in hydrogen (H) plasmas.

Recent experiments on the TCV tokamak have been conducted to document the H-mode power threshold P_{LH} for L-H transitions driven by NBH for Hydrogen and Helium plasmas and to compare with Deuterium cases. For pure plasmas, a good agreement with the ITPA scaling is found provided that q_{95} is sufficiently low ($P_{LH}(H)=2.1P_{LH}(D)$ and $P_{LH}(He)=1.4P_{LH}(D)$) in agreement with previous results for transitions with ohmic heating only [1]. Adding small amounts of D to H plasmas showed, however, a rapid decrease of the threshold towards the D value suggesting doping of H-plasmas as an option to lower P_{LH} in the pre-nuclear phase of ITER.

Lowering the power threshold of H-plasmas with He doping has been recently investigated in AUG and JET showing different results: on JET a reduction of $P_{LH}(H)$ up to 40% is observed for an He concentration of about 10% is added [2] while, on AUG, P_{LH} stays constant up to c_{He} = 20% [3]. On TCV, the effect of He doping on H-plasmas has been investigated and results will be presented. Estimates of the Helium concentration, based on measured charge-exchange (CX) reactions of He III with the atoms of the neutral injector, will be detailed.

[1] R Behn et al 2015 Plasma Phys. Control. Fusion **57** 025007
[2] J. Hillesheim et al 2018 *Implications of JET-ILW L-H transition studies for ITER* Preprint: 2018 IAEA Fusion Energy Conf. (Gandhinagar, India, 22–27 October 2018)
[3] U. Plank et al 2020 Nucl. Fusion 60 074001

[a] See appendix of "H. Reimerdes, Overview of the TCV experimental programme" to be published in Nuclear Fusion, 2021