JET L-H transition studies: overview and relevant results towards ITER operation

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The understanding of the physics governing the transition from L- to H-mode confinement regimes is essential to optimize ITER operations with different gases and to design DEMO plasma scenarios. From the installation of the ITER-like wall in JET, several experimental campaigns investigated the physics of L-H transition, with Helium and different hydrogen isotope plasmas. We present here an overview with the most recent results of JET L-H transition studies, with relevant impact on ITER operation. ITER foresees a preliminary phase, called Pre-Fusion Operating Power phase, at reduced toroidal field with either H or He main gas, to study ELMy H-mode plasmas without neutron production. The prediction of L-H power threshold is critical for this first phase. JET He plasmas show that the density at which the power to access the H-mode is minimum ($n_{e,min}$) is significantly higher than H and D cases, in contrast to ASDEX-Upgrade findings of similar $n_{e,min}$ values for H, D and He plasmas [1]. Regarding the isotope effect on the L-H transition, recently, JET RF-heated Tritium shots showed that the power threshold in RF-heated Tritium plasmas is not necessarily lower than in Deuterium, in contrast to what was found previously with JET C-wall. NBI Tritium pulses expected later in the current campaign will hopefully help to further understand this unexpected isotope effect. Deuterium plasmas have been further investigated, characterizing the pre-transition phase and carrying out a detailed power balance analysis. The effect of plasma shape on the power threshold is confirmed from the last JET campaigns, and a new scaling law for JET D L-H transitions with explicit shape dependence has been proposed [2]. The non-linear behavior of $P_{L\text{-}H}$ versus plasma density and the presence of $n_{e,min}$ is shown to be captured for JET D NBI shots by a phenomenological model recently proposed [3], and it seems related to the occurrence of electron or ion heating at the transition. Lastly, the ion heat channel role in the transition has been investigated for JET NBI D discharges, showing that the ion heat flux is not monotonic in density [4], differently to RF-heated plasmas of ASDEX-Upgrade and Alcator C-mod [5].

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[5] M. Schmidtmayr et al Nucl. Fusion 58 (2018) 056003