Type I ELM to Type III ELM transition on JET

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The Type III ELMy H-mode scenario offers an attractive alternative to the Type I ELMy H-mode scenario for baseline operation in ITER as it features small ELM energy losses and can coexist with detached divertor conditions. In JET, the Type III ELMy H-mode is characterized with small ELMs (<<50kJ) and high ELM frequency (hundreds of Hertz) [1]. On the down side the Type III ELMy H-mode features lower confinement at $H_{98} < 0.8$ compared to $H_{98} = 1$ for Type I ELMy H-mode plasmas. In addition to the use of the regime as an operational scenario, the Type III ELMy H-mode regime is relevant for the back transition from H-mode to L-mode in ITER as it provides an intermediate step between the Type I ELMy H-mode and L-mode, and hence offers a possible recipe for a soft landing of the baseline H-mode scenario. The study of the transition from Type I to III ELMy H-mode is therefore important for both 1) the characterization of the confinement of the two regimes; and 2) the study of a pathway to a smooth H-mode landing.

In [2] it has been shown that Type III ELMs in JET occur over a wide range of pedestal densities and temperatures, and that the transition from Type I to Type III ELMs can be identified in the $T_{e,ped}$, $n_{e,ped}$ parameter space; at low collisionality ($\nu_{eff} < 0.5$) the transition follows a constant pressure curve ($T_{e,ped} \times n_{e,ped}$ = constant) below which type III ELMs occur, whereas at high collisionality ($\nu_{eff} > 0.5$) the transition can be characterized by a critical temperature T_{crit} [see also 3]. A model for this transition was proposed in [4, 5] where for low collisionality $T_{crit} \sim q^{18/5} \times B_0^2/n_{ped}^{6/5}$ and for high collisionality $T_{crit} \sim q^{24/17} \times B_0^{10/17}$. Here we will focus on the high collisionality branch of the Type III ELMy H-mode as studied in [1]. An important finding in [1] was that the plasmas confinement showed an apparent beneficial scaling with plasmas current. In a scan from I_p= 2.5 to 3.3 MA (q_{95}~2.8) the confinement increased from H_{98}~ 0.7 to 0.8. The question we want to address in this paper is whether this confinement improvement is due to the increases plasmas current or whether is it affected by the proximity of the plasmas in [1] the Type I to III ELM transition.

The Type III ELMy H-mode database in [1] was extended with Type I and mixed Type I/III ELMy H-modes from [3] with (q_{95} ~ 3.5 and I_p =2.5 MA) to help testing the proximity to the transition. The range of collisionality was 0.7 - 8.25. We observed gradual transition in confinement between Type I ELMy H-mode and Type III H-mode shots. A scaling of confinement vs. $T_{ped}/(q^{24/17} \times B_0^{10/17})$ was analyzed and indeed the critical temperature model sorts the data well. The transition between the Type I and III ELMy H-modes complicates the identification of the ELM regime and shows that confinement degradation is also gradual. Future experiments aiming to characterize the confinement of Type III ELMy H-mode plasmas therefore need to take great care to identify the proximity to the Type I to Type III transition.

References

[1] Rapp J et al, Nucl. Fusions 49 (2009) 095012 (11pp)

[2] Sartori R et al, Plasma Phys. Control. Fusion 46 (2004) 723

[3] Giroud C et al, submitted to Nucl. Fusion (2011)

[4] Pogutse O et al, Proc. 26th EPS on Controlled Fusion and Plasma Physics 23,I, 249

[5] Igitkhanov Yu et al, Contrib. Plasma Phys. 40 (2000) 368