Transition from no-ELM response to pellet ELM triggering during pedestal build-up — insights from extended MHD simulations

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ITER operation is based on the H-mode regime with controlled Edge Localized Modes (ELMs), i.e., ELM power losses which do not cause excessive erosion of plasma facing components. One control method foreseen for ITER is to increase the ELM frequency by periodic injection of small pellets, thereby reducing the energy losses by each individual ELM [4]. Reliable pellet ELM pacing has been demonstrated by experiments in JET, ASDEX Upgrade and DIII-D [1-3]. This technique allows to reduce energy losses by each individual ELM and is considered for ITER [4]. However, further understanding of the physics principles guiding the interaction of ELMs with pellets and of the requirements for pellet conditions (size, speed, etc.) are needed to guarantee reliable ELM triggering.

Experimental observations show that the frequency of ELM pacing by pellet injection cannot be increased arbitrarily due to a so-called lag-time. During this time after a preceding natural or triggered ELM crash, neither a natural ELM crash occurs nor the triggering of an ELM crash by pellet injection is possible. Recently, simulations of periodic type-I ELM cycles in ASDEX Upgrade were performed for the first time [5]. Based on this setup, ELM triggering simulations were carried out by injecting pellets at various times in the inter-ELM phase to analyze the lag-time and the transition into the ELM triggering regime for the first time [6]. Comparisons to simulations of natural ELM crashes were performed [7].

In this contribution, our findings regarding lag-time and stochasticity will be discussed; Simulations with $0.8\text{x}10^{20}$ deuterium atoms injected (corresponding to a $1.5\text{x}10^{20}$ pellet before guide tube losses in the experiment) show a sharp transition of the energy losses between early ($t<10$ ms) and later ($t>12$ ms) injection times which correspond to different stages of pedestal build-up. The toroidal mode spectrum is significantly broader when an ELM is triggered, enhancing the thermal energy losses by perpendicular convection as well as parallel conduction in the stochastic magnetic field. Simulations show reduced ELM sizes for pellet injection right after lag-time, albeit with a slightly narrower wetted area on the divertor.

References

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