Recent advances on stationary no-ELM and small-ELM regimes

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For future magnetic fusion devices, the mitigation or even full suppression of edge localized modes (ELMs) is required to avoid erosion of the divertor target plates from the heat and particle fluxes caused by type-I ELMs. Stationary no-ELM and small-ELM regimes have recently regained attention as alternative scenarios as their ELM energy loss is sufficiently small to obtain minimal transient heat and particle loads combined with sufficient ELM impurity exhaust and an energy confinement close to type-I ELMy H-mode for the same machine engineering parameters.

Several 'natural' ELM-free and small-ELM regimes have been obtained in various tokamaks, such as the 'Quiescent' H-mode (QH-mode) [1] and its wide-pedestal variant [2], the improved energy confinement mode (I-mode) [3], the EDA-H-mode [4,5], the type-II [6] and 'grassy' ELM-regime [7] and negative triangularity L-modes featuring high confinement [8,9]. While the different regimes all have different characteristic signatures, one commonality unifies them: a mechanism is activated that changes the transport [10] and the structure of the pedestal in such a way that it becomes stable against peeling-ballooning modes and thus, no type-I ELM can occur. In order to open the existence space for the activation of this mechanism and to cause a high enough transport level to significantly change the pedestal structure, certain boundary conditions have to be introduced. These boundary conditions could be ascribed to shaping (including positive and negative triangularity), rotational shear, magnetic shear, operation in the unfavourable ∇B drift configuration, amongst others.

Substantial progress in understanding and extending the operational space of stationary no-ELM and small-ELM regimes has been made in the past years. The state-of-the-art of these scenarios is presented and the access and sustainment as well as their applicability to ITER and DEMO are discussed.

References

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