The quiescent H-mode regime for high performance ELM-stable operation in future burning plasmas

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Abstract. For the first time, DIII-D experiments have achieved stationary quiescent H-mode (QH-mode) operation for many energy confinement times at simultaneous ITER-relevant values of beta, confinement, and safety factor, in an ITER similar shape. QH-mode provides excellent energy confinement, even at very low plasma rotation, while operating without edge localized modes (ELMs) and with strong impurity transport via the benign edge harmonic oscillation (EHO). By tailoring the plasma shape to improve the edge stability, the QH-mode operating space has also been extended to densities exceeding 80% of the Greenwald limit, overcoming the long-standing low-density limit of QH-mode operation. In the theory, the density range over which the plasma encounters the kink-peeling boundary widens as the plasma cross-section shaping is increased, thus increasing the QH-mode density threshold. The DIII-D results are in excellent agreement with these predictions, and nonlinear MHD analysis of reconstructed QH-mode equilibria shows unstable low n kink-peeling modes growing to a saturated level, consistent with the theoretical picture of the EHO. Furthermore, high density operation in the QH-mode regime has opened a path to a new, previously predicted region of parameter space, named "Super H-mode" because it is characterized by very high pedestals that can be more than a factor of two above the peeling-ballooning stability limit for similar ELMing H-mode discharges at the same density.

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