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Access to a New Super H-mode Regime By Manipulation of Pedestal Stability[1]

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A physics understanding of constraints on the H-mode pedestal has enabled access to higher pedestal pressure on DIII-D and the potential for more favorable scenarios for future devices. The pedestal height is limited due to coupled peeling-ballooning modes (PBMs) and the highest pressure consistent with PBM stability is obtained at the transition between the peeling and ballooning branch. When PBM and kinetic ballooning mode (KBM) constraints are coupled in the EPED pedestal model, the effect of shaping on the maximum pedestal pressure is amplified and can lead to a splitting of predicted pedestal solutions into an H-mode and "Super H-mode" (SH) root, where the SH root with higher and wider pedestal can be reached following a specific density trajectory. On DIII-D, a theory-guided search for SH-mode has resulted in pedestal heights twice that of regular H-mode at the same density, accessed by controlling the edge bootstrap current with increasing density. EPED calculations of the pedestal height versus density are in quantitative agreement with experiment. SH-mode was first achieved with a Quiescent H-mode edge, enabling a smooth trajectory through pedestal parameter space. While elimination of ELMs is beneficial for SH-mode, it may not be a requirement, as recent experiments maintained high pedestals with ELMs triggered by lithium granule injection. Experiments exploiting SH-mode by coupling it with a high performance core have resulted in plasmas with H-mode confinement factors > 1.2, normalized beta$\sim$3 and normalized pedestal beta twice that required for ITER. With higher pedestals, SH-mode improves prospects for steady-state scenarios with high bootstrap fraction and increased ideal wall stability limit, and may simultaneously provide a solution to maintaining high confinement at high density.

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