

High Fusion Performance in Super H-Mode Experiments on Alcator C-Mod and DIII-D

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The “Super H-mode” regime is predicted to enable pedestal height and fusion performance substantially higher than for standard H-mode operation. This regime exists due to a bifurcation of the pedestal pressure, as a function of density, that occurs in strongly shaped plasmas above a critical density. Experiments on Alcator C-Mod and DIII-D have achieved access to the Super H-Mode regime, and obtained very high pedestal pressure, including the highest pedestal pressure ever achieved on a tokamak ($p_{ped} \sim 80$ kPa) in C-Mod experiments operating near the ITER magnetic field. DIII-D Super H experiments have demonstrated high performance, including the highest stored energy in the present configuration of DIII-D ($W \sim 2.2$ - 3.1 MJ), while utilizing only about half of the available heating power ($P_{heat} \sim 6$ - 12 MW). These DIII-D experiments have achieved the highest value of peak fusion gain, $Q_{DT,equiv} \sim 0.5$, ever achieved on a medium scale ($R < 2$ m) tokamak. Sustained, stationary high performance operation has been achieved utilizing $n=3$ magnetic perturbations for density and impurity control. Super H-Mode access is predicted for ITER and expected, based on both theoretical prediction and observed normalized performance, to enable ITER to achieve its performance goals ($Q=10$) at $I_p < 15$ MA, and to enable more compact, cost effective DEMO designs. We present extensive comparisons of Super H theory to experiments on C-Mod and DIII-D, predictions for Super H access on JET, JT-60SA & ITER, and coupled core-pedestal predictions of fusion performance on existing and future devices.

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