# A critical edge ion heat flux for L-H transition from combined analysis using Alcator C-Mod and ASDEX Upgrade tokamaks*

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Experimental studies of the transition from L-mode to H-mode confinement (L-H) on Alcator C-Mod and ASDEX Upgrade (AUG) strengthen the basis for projecting power requirements for future fusion devices. On C-Mod, L-H experiments at toroidal field $B_T$ of 4.0—7.8T reveal that H-mode power threshold $P_{th}$ accords roughly with projections from a scaling law used to determine power needs for ITER. However, as on AUG, the scaling law does not capture the experimental density dependence of $P_{th}$ at low normalized density $\bar{n}/n_G$. Furthermore, at higher line averaged density $\bar{n}$ the inferred experimental $P_{th}$ does not scale as strongly with $B_T$ as the scaling law indicates [1]. We can partially resolve these discrepancies by performing transport and power balance analysis of C-Mod plasmas just prior to L-H transitions [2]. Analysis confirms and extends a key result found on AUG: a critical value of surface-integrated ion heat flux per particle $Q_i/\bar{n}$ is necessary to enable the transition from L-mode to H-mode [3]. The analysis of C-Mod data indicates that $Q_i$ at the L-H transition not only increases linearly with $\bar{n}$ but also with $B_T$. The $\bar{n}$, $B_T$ scalings are not necessarily reflected in the experimental total L-H power because of changing balance of edge electron and ion heat fluxes, which depends in turn on the auxiliary heating scheme and the strength of electron-ion equilibration. Combining data from C-Mod and AUG yields a general expression for the edge ion heat flux at the L-H transition, $Q_i/S \propto \bar{n}^{1.07}{B_T}^{0.76}$, where $S$ is the plasma surface area. This result is consistent with a critical shear in edge $E \times B$ being necessary for H-mode access, and can explain the $\bar{n}$, $B_T$, and $S$ dependencies in the $P_{th}$ scaling law, providing an additional means of extrapolating H-mode power requirements to ITER.

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