I-mode: An H-mode Energy Confinement Regime with L-mode Particle Transport in Alcator C-Mod*

E. Marmar, A. Hubbard, D. Whyte, I. Cziegler, A. Dominguez, M. Greenwald, N. Howard, J.W. Hughes, B. Lipschultz, R. McDermott[1], J. Rice, J. Terry and the Alcator C-Mod Team

MIT Plasma Science and Fusion Center, Cambridge MA 02139 USA

[1]Current address: Max-Planck Institut fur Plasmaphysik, Garching, Germany

A regime of operation is investigated which features a strong edge thermal transport barrier, with little or no particle/impurity barrier. There is generally no increase in density or impurities; impurity particle confinement is at L-mode levels, and no drop in D_α emission is seen. I-mode is obtained on Alcator C-Mod in single-null diverted discharges with ion grad-B drift away from the active X-point, using strong ICRF auxiliary heating. An E_r well develops in this regime [1], and in many cases a clear bifurcation from L-mode edge temperatures is seen. Changes in turbulence are observed at the same time, localized to the edge by reflectometry and gas puff imaging measurements. As in L-mode, SOL and divertor density profiles remain broad, beneficial for power handling, impurity shielding and ICRF coupling. Originally an abbreviation for "Improved L-mode" [2], it is now clear that I-mode is not a low energy confinement regime, with $H_{98(y,2)}$ up to 1.2 achieved so far on C-Mod. Other attractive features of I-mode include: reduction, compared to H-modes, of impurity radiation with a high-Z metallic wall; compatibility with low Z impurity seeding to further decrease divertor power loading; access to stationary, collisionless pedestals ($\nu^*\sim0.1$, pedestal temperature up to 1 keV); excellent density control with cryopumping; and no need for large ELMs to regulate pedestal particle transport (although occasionally small ELMs are seen in some of the highest pressure pedestal cases). I-mode has been obtained over a wide parameter range (B=3-6 T, I_p=0.7-1.3 MA, q_{95}=2.5-5). Generally, highest pressure pedestals and normalized energy confinement are found at low q_{95} (≤ 3.5), and high heating power (≥ 4 MW). I-mode global energy confinement shows a relatively weak degradation with input power (P), yielding stored energy proportional to $I_p x P^{0.75}$. Detailed studies of H-mode threshold show that the thresholds for formation of the edge density barrier are not simply a factor of two above those for the favorable grad-B drift direction; for the highest currents (lowest q_{95}), they can be as much as a factor of 3 or more times the standard scalings.

[1] R. McDermott, et al, Phys. Plasmas **16** 056103 (2009).

[2] F. Ryter et al, Plasma Phys. Control. Fusion **40** 725 (1998)

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