Conditions for and dynamics of transitions from I-mode to H-mode on Alcator C-Mod*

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The I-mode regime of operation, with a thermal transport barrier and no particle transport barrier, is now accessed on several tokamaks, normally with the ion $\mathbf{B}\times\nabla\mathbf{B}$ drift away from the active divertor. Characteristic turbulence features include a decrease in mid-frequency turbulence (~50-150 kHz), the appearance of a Weakly Coherent Mode at higher frequency, and a GAM fluctuation in poloidal flow [1,2]. The L-I power threshold is quite well characterized, increasing with density, current and device size and with only weak dependence on B_T[3]. Perhaps the biggest question for application of the regime to high performance plasmas is the threshold for I-H transitions. These have been found rather more variable than L-I transitions, and early attempts to create an empirical global power scaling were unsatisfactory [4]. A clear result, favorable for high field devices, is that the upper range of power for I-mode increases with magnetic field.

We investigate here the typical sequence and conditions leading up to I-H transitions on C-Mod, including turbulence and pedestal profiles, with the aim of improving understanding and therefore ability to extrapolate. There appear to be different regimes and routes to these transitions, which can have different behavior. At the transition to H-mode, in all cases, there is a strong and prompt suppression of turbulence across the frequency spectrum. At relatively low field on C-Mod (eg 2.8 T), quite a small increase in power above the L-I transition can lead to an H-mode; in some cases discharges evolve to H-mode at constant power. This is similar to observations on other tokamaks [3]. In these cases little change is seen in I-mode turbulence leading up to the transition. At higher field (5-6 T), the I-H power threshold is much higher and at moderate density can often exceed the available ICRF. However, as density is increased at constant power, transitions to H-mode often occur. This upper density limit increases with input power. In these cases, density and magnetic turbulence spectra often show a slow evolution as the transition is approached. Notably, moderate frequency turbulence (~50 kHz) starts to increase towards L-mode levels though the WCM remains. We are examining the local conditions for these changes (eg T_e, gradients, collisionality).

I-H transitions can also occur if an I-mode discharge, formed with $\mathbf{B}\times\nabla\mathbf{B}$ drift away from the X-point, is shifted to the opposite X-point (eg LSN to USN). I-modes have been sustained near DN but not with drifts toward the active X-point. In these cases turbulence again gradually changes to more L-mode like spectra before the H-mode transition. Analysis of these local changes may help to explain the mechanisms by which I-mode, with its intriguing separation of transport channels, forms and the role of magnetic configuration.

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2 CZIEGLER I. *et al* 2013 Phys. Plasmas **20** 055904.
3 HUBBARD A.E., OSBORNE T., RYTER F. et al, IAEA 2014, submitted to Nuclear Fusion.
4 HUBBARD A.E. *et al* 2012 Nucl. Fusion **52** 114009.

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