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EX/1-3: Progress in Performance and Understanding of Steady ELM-free I-modes on Alcator C-Mod

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The I-mode regime of operation has been extended in recent Alcator C-Mod campaigns in duration and robustness, over a wide range of parameters. This attractive regime features an edge thermal barrier, and H-mode like energy transport, in combination with L-mode like density profiles and particle transport. This prevents accumulation of impurities, and means that ELMs are not needed to expel them. I-modes are now routinely maintained in stationary conditions for over 10 τ_E . They are usually ELM free, a key advantage given the concern over divertor heat pulses on ITER. Instead, a continuous pedestal fluctuation appears to enhance selectively particle over thermal transport [2]. High performance I-modes are usually obtained with unfavourable ion drift direction. They have been produced in both upper and lower null plasmas, with $q_{95} = 2.5$ -5.3 and extending to low ν^* . τ_E is in the range of H-mode, with $H_{98,y2}$ up to 1.2, and exhibits less degradation with power ($W \sim P^{0.7}$). Power thresholds for I-mode are somewhat higher than typical L-H scalings, and increase with I_p as well as with density. The widest power range for I-mode, nearly a factor of two above the L-I threshold, has been obtained in reversed field, lower null discharges at moderate n_e . Detailed measurements have been made of profiles and turbulence in the edge pedestal region, aiming to understand the separation of particle and energy transport. At the L-I transition, broadband turbulence in the 50-150 kHz range decreases. A pedestal-localized weakly coherent mode at ~200-250 kHz is observed on density, magnetic and Te diagnostics [3]. Stability analysis using ELITE shows that the pedestal is deeply stable to peeling-ballooning modes, consistent with the lack of ELMs. Initial assessments of the potential application of the I-mode regime on ITER, extrapolating from C-Mod results, indicate that an attractive operating scenario is possible, if issues of operation in the unfavourable drift configuration can be addressed. The L-I transition should be accessible at low density, and $Q=10$ is projected at $n_e = 5 \times 10^{19} \text{ m}^{-3}$. This exercise also highlights some of the key issues remaining to be addressed, on C-Mod and in joint experiments.

[1] Whyte D G et al 2010 Nucl. Fusion 50 105005 [2] Hubbard A E et al 2011 Phys. Plasmas 18 056115 [3] White A E et al Nucl. Fusion 51 (2011) 113005

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