Impact of the Pedestal on Global Performance and Confinement Scalings in I-Mode

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Abstract. I-mode is a novel alternate high-confinement tokamak regime, notable for the formation of a strong temperature pedestal with associated H-mode-like increase in energy confinement, without the accompanying density pedestal or suppression of particle transport. I-mode exhibits a number of attractive features for a tokamak reactor regime, namely (1) an inherent lack of large, deleterious Edge-Localized Modes (ELMs), (2) minimal impurity accumulation and radiative loss compared to conventional H-modes, and (3) an apparent lack of strong degradation of energy confinement with input heating power. Previous analyses of I-mode experiments at Alcator C-Mod have elucidated the pedestal structure in I-mode, particularly in its strong positive response to fueling and input heating power. Global performance and confinement responds accordingly to these inputs, with both absolute (*e.g.,* plasma stored energy) and normalized (*e.g.,* β_N) metrics responding strongly to fueling and heating power. Due to core temperature profile stiffness further effects?, the very high pedestal temperature in I-mode results in comparable core and global-averaged pressures to H-mode despite the relaxed density profile, although moderate levels of density peaking are still observed. The minimal degradation of energy confinement time with heating power in I-mode is also observed empirically, in contrast to the strong ($\tau_E \sim P^{-0.7}$) degradation found in H-mode. Following the practices of the multi-machine ITER89 and ITER98 confinement scalings for L-mode and ELMy H-mode respectively, an initial assay at a confinement scaling for I-mode is also presented. The single-machine scaling captures the physics observed on Alcator C-Mod ASDEX data influence? something something informs extrapolation to ITER

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1. Introduction

Viable & economical power generation via tokamak magnetic-confinement fusion is characterized by two seemingly-contradictory requirements. First, a high level of energy confinement is necessary for the desired level of self-heating by fusion products (*e.g.,* "alpha heating" for deuterium-tritium fusion) for net energy production. At the same time, particle confinement must be sufficiently low to avoid the deleterious effects of accumulated impurities (both the helium "fusion ash" and high-Z materials introduced from eroded plasma-facing surfaces) due to fuel dilution and radiative losses. The energy confinement requirement has been achieved in a class of operating regimes, collectively termed "H-modes" [1], characterized by the formation of a steep-gradient region at the plasma edge in density, temperature, and pressure, termed the *pedestal*, with H-modes capable of stationary operation requiring a relaxation mechanism on the density pedestal to avoid impurity accumulation.

References

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