Edge Localized Mode Control in DIII-D Using Magnetic Perturbation-Induced Pedestal Transport Changes*


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In DIII-D, large Type I ELMs are eliminated without degrading confinement using n=3 edge resonant magnetic perturbations (RMPs) in H-modes with ITER-relevant pedestal collisionalities $\nu^*_e \sim 0.1$ when the edge safety factor is in the resonant window $q_{95} = 3.7$. Linear peeling-ballooning stability analysis indicates that the Type I ELMs are suppressed by reducing the pedestal pressure gradient $\nabla p_{\text{TOT}}$ below the peeling-ballooning limit. This reduction is controlled by changing the RMP amplitude, and results from an increase in particle, not electron thermal transport. This result is inconsistent with stochastic layer transport theory. Density fluctuations in the pedestal increase, consistent with enhanced anomalous particle transport reducing $\nabla p_{\text{TOT}}$. In contrast, at $\nu^*_e \sim 4$, the Type I ELMs are replaced by small recycling fluctuations, possibly Type II ELMs, which are correlated with increased intermittent “blob” transport. Because the energy loss in each event is less than that from a Type I ELM but the number of these events increases, the divertor impulses are reduced while the overall transport is constant. This process produces values of $\nabla p_{\text{TOT}}$ which are nearly unchanged in the ELM-suppressed H-mode, suggesting that different mechanisms suppress the ELMs in the two $\nu^*_e$ regimes. At low $\nu^*_e$, fluctuation-driven transport increases, reducing $\nabla p_{\text{TOT}}$ below the stability limit. At high $\nu^*_e$, “Type II ELMs” are destabilized, leading to a limit cycle that holds $\nabla p_{\text{TOT}}$ just below the Type I ELM stability limit.

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