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Adaptive Real-Time Pedestal Control for DIII-D and Prospects for ITER

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A comprehensive adaptive real-time (rt) ELM control system that exploits key properties of ELM physics, Resonant Magnetic Perturbation (RMP) ELM suppression physics, and an extensive set of diagnostic inputs to make rt decisions about the control of multiple actuators to sustain ELM suppression/mitigation is demonstrated at DIII D. The control experiments showed the path dependence and hysteresis of plasma recovery: even for the same final perturbing 3D currents, starting with higher initial 3D currents leads to lower recovery down the path. This demonstrates the need for a control system to keep the ITER RMP perturbations close to the ELM suppression threshold at all times. The development at DIII-D initiates progress toward adaptive pedestal control, and includes pedestal profile control as well as ELM suppression/mitigation. 3D coil configuration and phasing for RMP ELM suppression is adjusted in real-time based on SURFMN calculations of the vacuum edge pitch-resonant, and kink-resonant harmonics of the applied 3D magnetic perturbation and offline IPEC data. The amplitude of the 3D coils is regulated to achieve a given ELM frequency (or none) using ELM detection based on the D_α measurements from the divertor region. For pedestal control, the Plasma Control System (PCS) acquires rt Thomson scattering diagnostic data and fits the pedestal width/height for temperature and density profiles. Based on the Thomson fits, PCS regulates the pedestal density by adjusting the gas-puffing rate to increase particle source and RMP density "pump-out"to reduce it. Real-time pedestal stability boundary calculation using a neural network based on EPED1 runs, and a real-time pellet injection control for turn on/off timing and ELM frequency are under development. These developments at DIII-D pave the way for ITER adaptive pedestal control.

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