The physics of edge resonant magnetic perturbations in hot tokamak plasmas

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ABSTRACT

Small edge resonant magnetic perturbations are used to control the pedestal transport and stability in low electron collisionality (ν_e^*), ITER relevant, poloidally diverted plasmas. The applied perturbations reduce the height of the density pedestal and increase its width while increasing the height of the electron pedestal temperature and its gradient. The effect of the perturbations on the pedestal gradients is controlled by the current in the perturbation coil, the poloidal mode spectrum of the coil, the neutral beam heating power and the divertor deuterium fueling rate. Large pedestal instabilities, referred to as edge localized modes (ELMs), are completely eliminated with radial magnetic perturbations ($\delta b_r^{(m/n)}$) at the $q = m/n$ =11/3 surface exceeding $\delta b_r^{(11/3)} B_\phi^{-1} = 2.6 \times 10^{-4}$ where B_ϕ is the toroidal magnetic field on axis. The resulting ELM-free H-mode plasmas have stationary densities and radiated power that have been maintained in DIII-D for up to 2550 ms (17 energy confinement times) and are limited only by hardware constraints. It is found that changes caused by the magnetic perturbations in the pedestal profiles cannot be explained by a straightforward application of stochastic quasi-linear diffusion theory due to the complex nature of the transport physics involved when boundary layer field lines connect regions of hot plasma directly to material surfaces.

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