Edge localized mode control using non-axisymmetric magnetic perturbations*

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The ability to control transient heat loads due to edge-localized modes (ELMs) is a critical requirement for the success of high-confinement (H-mode) tokamak fusion reactors. The application of non-axisymmetric magnetic perturbations to the edge of a tokamak can both stabilize and destabilize ELMs by altering H-mode edge transport [1]. Driving non-axisymmetric current through the scrape-off layer in order to generate the required magnetic perturbations can then provide a reactor-relevant ELM control solution [2]. The initial working hypothesis for the induced transport changes, stochastic magnetic transport [3], failed to explain why it is particle convection that is enhanced over thermal conduction, and why the divertor strike point does not develop the predicted toroidally asymmetric heat flux profile [4], but only an asymmetric particle flux profile [5]. At low collisionality, perpendicular drift rotation plays a crucial role in inhibiting reconnection [6,7]. The plasma behaves as a nearly ideal conductor except at two locations: (1) at the foot of the pedestal where resistivity is large and rotation is small and (2) at a location where the perpendicular electron velocity nearly vanishes and the electron impedance in Ohm's law becomes negligible. Whether or not an island forms, the helical changes in the magnetic field strength near the rational surfaces drive both toroidal and poloidal neoclassical viscous forces [8,9] that produce non-ambipolar transport and modify reconnection dynamics [10]. The increased rotation damping acts to suppress both global flow shear and zonal flows which can lead to enhanced turbulent transport [11]. In addition, when the rotation rate lies between the ExB and electron drift frequencies, two-fluid effects are predicted to generate convective transport through two separate effects: (1) the magnetic flutter flux points outward [12,13] and (2) the mode can spontaneously radiate electron drift waves [14,15]. In order to determine whether this technique will be successful in future devices, it is imperative to know which transport process dominates and how the transport scales to reactor-relevant regimes.

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