Halo currents flow for part of their path along the open magnetic field lines near the plasma edge and for part through the surrounding conducting structures. Halo currents act much as a resistive wall to slow the evolution of the plasma shape to the resistive time scale of the halo current τ_h and occur whenever the plasma would otherwise evolve more rapidly. Strong halo currents arise in tokamaks when axisymmetric equilibrium is lost. As the plasma pushes into the wall, which has a resistive time scale τ_w, the edge q drops when the resistive decay time of the plasma current τ_p satisfies $\tau_p > \tau_w$. When $q \sim 2$, a strongly unstable n=1 kink occurs, which in the absence of a halo current would have an Alfvénic growth. A halo current arises in proportion to the amplitude Δ_k of the kink and slows its growth to τ_h.

The evolution of the halo current is dominated by two properties when flowing through the edge plasma. (1) The edge plasma cannot balance a significant $\vec{j} \times \vec{B}$ force, so $\vec{\nabla} \cdot \vec{j} = 0$ implies $\vec{j} = (j_{\|} / B)\vec{B}$ with $\vec{B} \cdot \vec{\nabla}(j_{\|} / B) = 0$. Each tube of magnetic flux $\delta\psi$ acts as a wire carrying a current $(j_{||}/B)\delta\psi$. (2) The halo current channel has a minimum radial width Δ_h, which must be comparable to the amplitude Δ_k of the n=1 kink. Geometry implies the halo current can only flow between the plasma and the wall in a region of toroidal angular extent $\delta\varphi \approx \sqrt{2\Delta_h / \Delta_k}$. When $\delta\varphi << 1$, the toroidal coupling is so strong that the energy released by the unstable n=1 kink is not sufficient to drive the coupled $n \neq 1$ kinks, which are stable.

Toroidally rotating halo currents can be particularly destructive. Rotation arises when the energy released by the n=1 kink depends on the toroidal frequency ω of the kink. The torque required to change the kink rotation from the frequency that maximizes the energy release is related to the ω dependence of this release by the Kramers-Kronig relations, which are implied by causality.

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