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Observation and Quasilinear Modeling of Rotation Reversal Hysteresis in Alcator C-Mod Plasmas

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Analysis and modeling of a new set of rotation reversal hysteresis experiments unambiguously show that changes in turbulence are responsible for the intrinsic rotation reversal and the Linear to Saturated Ohmic Confinement (LOC/SOC) transition on Alcator C-Mod. Plasmas on either side of the reversal exhibit different toroidal rotation profiles and turbulent fluctuations despite having profiles of density and temperature that are indistinguishable within measurement uncertainty – suggesting a bifurcation process. The observed rotation profiles require turbulent residual stress, which is turbulent radial toroidal momentum flux not proportional to the toroidal velocity or its gradient. Since drift wave turbulence is typically driven by mean density and temperature gradients, these profiles place a tight constraint on possible mean field mechanisms for generation of the residual stress. This constraint is quantified by adopting a linear mode quasilinear transport approximation (mQLTA), where turbulent fluxes are expressed as the sum over the linear mode spectrum of a quasilinear weight, calculated through linear gyrokinetic simulation, and an unknown spectral weight, representing mode population. In this mQLTA framework, the deactivation of subdominant (in linear growth rate and heat transport) ion-scale ITG and intermediate-scale TEM-like instabilities is identified as the only possible change in turbulence across the reversal which is consistent with the experimentally measured profiles and the inferred heat and particle fluxes. Thus, this work provides strong evidence against the long-standing conjecture that the LOC/SOC transition is indicative of a change in the dominant ion-scale drift-wave instability, and suggests a path for understanding the LOC/SOC transition and rotation reversal hysteresis through the dynamics of subdominant modes and changes in their relative populations.

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