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Rotation Reversal and Energy Confinement Saturation in Alcator C-Mod Ohmic L-mode Plasmas: A Novel Transport Bifurcation

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Direction reversals of intrinsic toroidal rotation have been observed in Alcator C-Mod Ohmic L-mode plasmas following modest electron density or toroidal magnetic field ramps. Rotation reversals exhibit both a threshold and hysteresis, and thus constitute a momentum transport bifurcation. The reversal process occurs in the plasma interior, inside of the q = 3/2 surface. For low density diverted plasmas, the rotation is in the co-current direction, and can reverse to the counter-current direction following an increase in the electron density above a certain threshold. Reversals from the co- to counter-current direction are correlated with a sharp decrease in density fluctuations with 2 cm^{-1} $< k_q <$ 11 cm^{-1} and with frequencies above 70 kHz. The density at which the rotation reverses increases linearly with plasma current, and decreases with increasing magnetic field. There is a strong correlation between the reversal density and the density at which the global Ohmic L-mode energy confinement changes from the linear to the saturated regime. Taken together, these results suggest that reversals result from a change in the sign of the turbulence driven intrinsic torque density, proportional to the radial gradient of the residual stress. This change is predicted to accompany the evolution from TEM turbulence in LOC to ITG driven turbulence in SOC, and is a consequence of the scaling of the residual stress with the mode diamagnetic velocity.