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Edge Radial Electric Field Structure on Alcator C-Mod and its Connection to H-Mode Confinement[1]

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High-resolution charge-exchange recombination spectroscopy measurements using B^{+5} ions have enabled the first calculations of the radial electric field in the C-Mod edge. These observations, made in discharges with no externally applied torque, provide for important comparisons with other devices and offer new challenges for theory and simulation. Qualitatively, the field structure on C-Mod, computed from the B^{+5} radial force balance equation, is similar to that observed on other tokamaks. However, the depths of the C-Mod E_r wells (up to 300kV/m) are unprecedented – over twice as deep as on other devices and the narrow well widths (∼5mm) suggest a scaling with machine size. The poloidal velocity is found to be the dominant term in the force balance equation contributing up to 200kV/m transiently after L-H transitions and up to 80kV/m during steady H-modes. This differs from measurements on other tokamaks, in which the diamagnetic term is dominant. The radial electric field during EDA H-modes is steady in time, while a clear evolution of the E_r well depth is observed in ELM-free H-modes. The depth of the well decays as the electron temperature pedestal height (T_{ped}) decreases due to increases in P_{rad}. Interestingly, it is the poloidal VxB term, not the diamagnetic term, which decays. In fact, the diamagnetic term is observed to make a fixed contribution to E_r independent of confinement and pedestal heights, while the poloidal velocity contribution scales with T_{ped}, qualitatively consistent with the neo-classical formulation that poloidal impurity flows are driven in part by ion temperature gradients. As a further important observation, we have compared E_r with an estimate of the main ion diamagnetic term and found that they are roughly equal, indicating that the VxB term for the main ions is small.

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