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Measurement and Gyrokinetic Simulation of Impurity Transport in the Core of Alcator C-Mod[1]

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Measurements of impurity transport in the core of tokamak plasmas are compared with nonlinear gyrokinetic simulations for the first time. At Alcator C-Mod, a novel multi-pulse laser blow-off system introduces a measured source of trace, non-intrinsic impurity (calcium) with precise timing. Unique measurements provided by a high resolution x-ray crystal spectrometer allow for precise characterization of the time evolving profile of a single charge state (Ca^{+18}) of the trace impurity over the radial region $0.0 < r/a < 0.6$. Simulated emission by the trace impurity is obtained using the STRAHL code. A chi squared minimization of the difference in measured and simulated emission is used to determine time-independent transport coefficients and perform rigorous error analysis. Presented here are results from two experimental scans: a scan of plasma current ($I_p = 0.6 - 1.2$ MA) and a scan of ICRH input power (P_{in} =1.0 - 3.3 MW). Plasma current is well correlated with increased impurity confinement time and reduction in the density gradient scale length, a/L_n, and safety factor, q. Experimental values of diffusion and inward convection are found to decrease with I_p. This trend is well reproduced in global, nonlinear GYRO simulations and shown to be the result of reduced core safety factor (and magnetic shear) at high values of I_p. Addition of ICRH power results in decreased Ion Temperature Gradient (ITG) turbulence drive and a transition to Trapped Electron Mode (TEM) dominated core turbulence. During this scan, diffusion decreases and inward convection increases modestly, in contrast to initial gyrokinetic results which predict significant reduction of diffusion and inward convection. Extended analysis which includes high fidelity GYRO simulations and critical comparison between measured and predicted impurity transport will be presented.

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