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Imaging Main-Ion and Impurity Velocities for Understanding Impurity Transport in the Tokamak Boundary[1]

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Imaging of ion velocities throughout the scrape off layer (SOL) combined with 2D and 3D numerical fluid modeling is establishing the roles of frictional coupling, ion-thermal forces, and parallel pressure gradients in determining impurity and momentum transport on open magnetic field lines. Velocity measurements of C_2^+ impurity ions alongside He^+ main-ion species enabled the first quantitative measurements of the entrainment of impurity velocities with the main ion species in the divertor and main-chamber SOL. Changing poloidal location of the parallel-B flow stagnation point in H-mode plasmas has been observed as has velocity slowing in both species of up to 10km/s at the mid-plane during detachment. In these cases the direction of the flow relative to the magnetic field direction implies cross-field drift effects are important for determining parallel transport along field lines. UEDGE simulations of these plasmas identify how the ratio of frictional and grad-T_i forces balance to determine bulk impurity transport; the degree of entrainment of impurities is expected to vary throughout the SOL, and as a function of power and density. These 2D measurements have been achieved using two coherence imaging spectroscopy systems on DIII-D calibrated with a tunable diode laser to a velocity accuracy better than 1 km/s. In addition, 3D C_2^+ flow perturbations were observed in the vicinity of large coherent n=1 islands produced by external RMP coils. A poloidally alternating pattern of acceleration and deceleration, correlated to island positions, was observed with local velocity changes up to 10km/s and a length scale of 30-40cm. Comparison with EMC3-EIRENE simulations indicate that these perturbations result from temperature-driven parallel pressure gradients.

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