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EX/P3-19: Measurement of Deuterium Ion Toroidal Rotation and Comparison to Neoclassical Theory in the DIII-D Tokamak

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Recent experimental comparisons of the bulk deuterium ion toroidal rotation to neoclassical theory have revealed a significant discrepancy with neoclassically predicted bulk ion toroidal rotation. Performance of ITER plasmas will depend strongly on the level of main-ion toroidal rotation achieved due to the beneficial effects of rotation for stabilization of MHD as well as the toroidal rotation contribution to the radial electric field and associated ExB shear stabilization of turbulence. Recent measurements of the main-ion toroidal rotation in deuterium plasmas have been made through new spectroscopic capabilities and integrated modeling. Neoclassically the main-ion species is generally predicted to rotate faster in the co-current direction than impurity ions. However, recent measurements of carbon and deuterium ion toroidal rotation in ECH dominated H-mode conditions have revealed than the main-ions rotate slower than carbon in the co-current direction, opposite to the neoclassical predictions, and similar to previous measurements in helium plasmas. The discrepancy lies in the neoclassical prediction of the main-ion poloidal rotation. We compute the main-ion poloidal rotation from our direct measurements and find that the deuterium ion poloidal flow velocity is significantly larger than neoclassical theory from NCLASS predicts. In low toroidal rotation ITER scenarios the performance will depend on the E_r shear stabilization of turbulence through toroidal rotation, poloidal rotation and pressure gradient contributions to the total radial electric field. The modeling of ITER performance displays a strong dependence on the predicted levels of toroidal rotation obtained by fixing the ratio of chi_psi/chi_i, however this ratio is poorly understood, and our current experimental databases of this scaling are based on measurements of impurity ions. As toroidal rotation approaches zero, E_r will be dominated by the pressure and poloidal rotation contributions; hence an accurate determination of the poloidal flow is required in plasmas with low toroidal rotation. This work supported in part by the U.S. Department of Energy under DE-AC02-09CH11466, DE-FC02-04ER54698 and SC-G903402.

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