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Validation of Kinetic-Turbulent-Neoclassical Theory for Edge Intrinsic Rotation in DIII-D Plasmas[1]

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Recent experiments on DIII-D with low-torque neutral beam injection (NBI) have provided a validation of a new model of momentum generation in a wide range of conditions spanning L- and H-mode with direct ion and electron heating. A challenge in predicting the bulk rotation profile for ITER has been to capture the physics of momentum transport near the separatrix and steep gradient region. A recent theory has presented a model for edge momentum transport which predicts the *value and direction* of the main-ion intrinsic velocity at the pedestal-top, generated by the passing orbits in the inhomogeneous turbulent field [T. Stoltzfus-Dueck, PRL 108, 065002 (2012)]. In this study, this model-predicted velocity is tested on DIII-D for a database of 44 low-torque NBI discharges comprised of *both* L- and H-mode plasmas. For moderate NBI powers (P_{NBI}<4 MW), model prediction agrees well with the experiments for both L- and H-mode. At higher NBI power the experimental rotation is observed to saturate and even degrade compared to theory. TRANSP-NUBEAM simulations performed for the database show that for discharges with nominally balanced - but high powered - NBI, the net injected torque through the edge can exceed 1 N.m in the counter-current direction. The theory model has been extended to compute the rotation degradation from this counter-current NBI torque by solving a reduced momentum evolution equation for the edge and found the revised velocity prediction to be in agreement with experiment. Projecting to the ITER baseline scenario, this model predicts a value for the pedestal-top rotation ($\rho \sim 0.9$) comparable to 4 kRad/s. Using the theory modeled - and now tested - velocity to predict the bulk plasma rotation opens up a path to more confidently projecting the confinement and stability in ITER.

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