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Testing Neoclassical and Turbulent Effects on Poloidal Rotation in the Core of DIII-D[1]

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A new method of measuring impurity poloidal rotation with charge exchange recombination spectroscopy has been developed for DIII-D [1], and is used to show poloidal spin-up at the formation of an internal transport barrier as well as poloidal rotation which is not neoclassical. Rotation is an essential part of tokamak plasma dynamics, and poloidal rotation, though typically smaller than toroidal rotation in present-day experiments with current-aligned neutral beam injection, can be particularly important when toroidal rotation is small, as is expected to be the case in future tokamaks such as ITER. These new measurements are focused on the core of DIII-D plasmas and their high spatial resolution in this region has been instrumental to showing that poloidal rotation makes a significant contribution to the high $E \times B$ shearing rate needed to sustain an internal transport barrier. In addition, measurements for a variety of low- and high-performance plasmas have been compared to neoclassical theory and shown both agreement and disagreement. All these measurements are aided by the fact that the new method does not require calculations to correct for the energy dependence of the charge exchange cross section or gyro motion during the finite excited state lifetime. Disagreement with neoclassical theory is not easily explained by a single global parameter and agreement was seen in unexpected regimes such as QH-mode. A possible explanation for disagreement between experiment and neoclassical theory is the presence of turbulence and turbulence-driven poloidal rotation. The role turbulence plays in poloidal rotation dynamics is important for future tokamaks and it is investigated through the use of turbulence diagnostics and GYRO simulation.

[1] C. Chrystal, et al., Rev. Sci. Instrum. **83**, 10D501 (2012).

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