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Generation and Sustainment of Rotation in Tokamaks[1]

W.M. SOLOMON, Princeton Plasma Physics Laboratory

Recent experiments on DIII-D, NSTX and C-Mod have led to new discoveries related to toroidal rotation in tokamaks, including evidence for an effective torque responsible for "intrinsic rotation" generation and the existence of a strong inward pinch of angular momentum. Measurements on DIII-D using a mix of co- and counter-neutral beam injection show an effective torque in the co-current direction for H-mode plasmas with a profile that is largely localized toward the edge. This shows consistency with theoretical models of non-diffusive momentum transport such as the "residual stress" driven for example by the turbulent Reynolds stress. New data from DIII-D show that the effective torque is modified by electron cyclotron heating, resulting in a counter torque inside of the deposition radius. Application of lower hybrid heating in C-Mod also modifies the intrinsic rotation, again presumably through modifications to the residual stress. In NSTX, experiments have demonstrated the existence of an inward momentum pinch of up 40 m/s, generally showing quantitative agreement with theoretical predications originating from consideration of low-k turbulence. Similar observations have been obtained on DIII-D and C-Mod, although in some cases the experimental pinch can significantly exceed the theoreticallt expected level. Significant inward pinches will directly affect the peakedness of the rotation profile in plasmas with minimal external torque and an edge drive for the intrinsic rotation. In plasmas with large rotation and strong $E \times B$ shear, ion thermal transport can be reduced to neoclassical levels in DIII-D and NSTX; however, diffusive momentum transport still remains highly anomalous. The common physics of momentum transport between the three devices is under investigation.

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