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Measurement and Modeling of Intrinsic Torque on DIII-D*

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Recent experiments on DIII-D have investigated the mechanisms responsible for driving intrinsic rotation in tokamak fusion plasmas. The effective torque associated with driving intrinsic rotation at the edge (ρ>0.8) of H-mode plasmas shows a clear dependence on the pedestal pressure gradient ∇P_{ped}. Such a dependence is qualitatively consistent with theoretical models describing $E \times B$ shear as a means of creating "residual stress", which can result in a net torque on the plasma and hence drive intrinsic rotation. However, direct measurement of the turbulent Reynolds stress using probes near the plasma boundary suggests that a model based on residual stress alone cannot adequately describe the observations of intrinsic rotation formation. Observations of a narrow rotation layer near the separatrix are compatible with a description of thermal ion orbit loss, and calculations show that the torque from such a process should vary with $\sqrt{T_i}$. We find that an excellent predictor of the edge intrinsic torque is obtained by including this dependence, together with the previously observed ∇P_{ped} dependence, in a regression fit of a wide range of H-mode conditions. The intrinsic torque in the core (ρ<0.5) of H-mode plasmas tends to be comparatively smaller than the edge, although some cases have been identified where the core intrinsic torque can substantially impact the rotation profile. For instance, in certain plasmas with electron cyclotron heating, a significant counter intrinsic torque has been observed in the inner region of the plasma.

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