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Intrinsic Rotation Generation in DIII-D ELM-free H-mode Plasmas*

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The turbulent Reynolds stress and edge plasma flows were measured during intrinsic-rotation generation in DIII-D ELM-free H-mode plasmas [S.H. Müller *et al*., Phys. Rev. Lett. (accepted) (2011)]. In these low-power conditions, a reciprocating multi-tip Langmuir probe can penetrate up to 1 cm inside the separatrix at the outboard midplane. A 1-cm wide rotation layer is observed at the separatrix, also seen in some L-modes [J.A. Boedo *et al*., Phys. Plasmas (accepted) (2011)], which rotates at 40 km/s in the co-current direction, independent of the injected torque. Independent evidence for the existence of the edge co-rotation layer comes from main-ion rotation measurements by charge-exchange-recombination spectroscopy in comparable helium plasmas. Inside the layer's peak, the measured fluid turbulent stress transports toroidal momentum outward, which can help sustain the edge rotation layer. However, this exerts a counter-current torque on the core, which is inconsistent with the co-current core spin-up. At the layer's peak and further outward, the measured Reynolds stress is essentially zero, due to low density, weak correlations between the toroidal and radial velocity fluctuations, and low fluctuation amplitudes in the sheared flow.

In the light of the experimental outcome, alternative mechanisms that could oppose the Reynolds stress and lead to a net co-current spin-up of the core were investigated. Strong charge-dependent ΓxB torques during the density rise are efficiently cancelled across species by inductive electric fields. Neutral friction cannot lead to a removal of counter-current momentum due to the non-observation of a rotation inversion point, leaving Maxwell stress and kinetic stresses as the remaining candidates. While Maxwell stress cannot be dismissed, kinetic stresses generated by ion orbit loss were investigated and found qualitatively consistent with the experiment. In particular, a simple orbit-loss model correctly predicts the qualitative features of the edge co-rotation layer, while underestimating its magnitude by a factor of two.

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