Evidence of an Edge Momentum Source in DIII-D H-mode Plasmas and Role of the Reynolds Stress for Intrinsic Rotation*

S.H. Muller, University of California-San Diego

Obtaining a predictive understanding of intrinsic rotation in tokamaks is an important issue for ITER. DIII-D experiments have inferred an "intrinsic torque" in the plasma edge region [Solomon et al., Nucl. Fusion **49** (2009) 085005], but a precise identification is still missing. Theory suggests an important role of the turbulent Reynolds stress [Gürcan et al., Phys. Plasmas **14** (2007) 042306], but insufficient experimental data exists to clarify its role.

Using a reciprocating multi-tip Langmuir probe, we present the first measurements of the toroidal-radial Reynolds stress in a tokamak H-mode pedestal and report the discovery of a strong co-current rotation layer. The 1-cm-wide layer, whose peak is located just inside the separatrix, forms independently of the injected torque within less than 50 ms after the L-H transition from a much smaller feature in L-mode. In pure ECH plasmas with zero applied torque, the core rotation profile is flat and spins up over 600 ms until the velocity of the edge rotation layer of 35 km/s is matched. This proves that the layer is the cause – not an effect – of the core rotation and suggests that viscous transport down the layer's gradient can slowly spin up the core. A simple orbit loss model was applied to a representative discharge and good agreement with the layer was found, suggesting a role of ion orbit losses in the formation of the layer.

The total toroidal-radial Reynolds stress is essentially zero outside the layer's peak and becomes increasingly positive further inward. It thus acts to oppose the spin-up of the core by transporting momentum back up the layer's gradient, thereby helping to maintain the peaked shape over such long timescales. This indicates that the stress also plays a key role in the physics of the edge rotation layer.

*Supported by the US DOE under DE-FG02-07ER54917 and DE-FC02-04ER54698.