On the physics of the scrape-off layer width*

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It is important to understand the scrape-off layer (SOL) of a magnetic fusion device in order to predict power and particle flux handling capabilities for next generation experiments and fusion reactors. However, the physics determining the scaling of the tokamak SOL width [1] is not well understood. The Goldston model [2], which is in good agreement with experimental data, assumes that the width is set by the poloidal ion gyroradius due to magnetic drifts in toroidal geometry. Yet this heuristic explanation lacks a sound theoretical explanation and the impact of turbulence is neglected in the model. Part of the difficulty in understanding the SOL is that this is a region where both collisional and collisionless effects compete for dominance.

The minimum SOL width is in fact given by the poloidal ion gyroradius because only electrons in the hot tail of the distribution can escape the confining sheath potential. In equilibrium, the hot electron flux incident on the target plate is smaller than the total electron flux by the square root of the mass ratio $(m_e/m_i)^{1/2}$. In equilibrium, the time to scatter into the hot tail is longer than the SOL transit time by precisely the inverse of this ratio. Thus, for plateau collisionality, the distance that an electron can travel before escape is on order of the poloidal ion gyroradius rather than the electron gyroradius. The SOL electric field confines ions near the midplane separatrix, while confining electrons near the divertor targets. The combination of neoclassical radial electric conductivity [3] and parallel Spitzer electrical conductivity generates a radially variation in the electric field that is also on the order of the poloidal ion gyroradius.

Gyro-Landau fluid models can be used to address both the neoclassical equilibrium and gyrokinetic stability of the tokamak edge. Landau fluid models have recently been extended [5] in a manner that accurately captures the collisional limit, i.e. so that the models reduce to the Braginskii equations. The combination of collisional Landau fluid closures with the gyro-fluid approach generates a neoclassical physics model that has the correct limit in both the high collisionality Pfirsch-Schluter regime and the weak collisionality plateau regime. Addressing the low collisionality banana regime requires the addition of trapped particle effects. Progress on GLF relevant models of SOL turbulence will be reported.

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[1] T. Eich, Phys. Rev. Lett. **107**, 215001 (2011)
[2] R. J. Goldston, Nucl. Fusion **52**, 013009 (2012).
[3] V. Rozhansky, E. Kaveeva, S. Voskoboynikov, et al., Phys. Plasmas **9**, 3385 (2002).
[4] I. Joseph and A. M. Dimits, accepted by Contrib. Plasma Phys. (2016).