Finite orbit width effects on neoclassical transport in large aspect ratio tokamaks

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In transport barriers, the applicability of standard neoclassical theory is limited because of sharp gradients of temperature, density, and radial electric field. We have developed a new neoclassical approach that sets the scale length in transport barriers to be the ion poloidal gyroradius. This ordering implies that the poloidal component of the $E \times B$-drift becomes of the order of the poloidal component of the typical ion parallel velocity and the trapped particle region is shifted. Using large aspect ratio and low collisionality expansions, we define a new set of variables based on conserved quantities, which simplifies the drift kinetic equation whilst keeping finite orbit width effects, and derive equations describing the ion transport of particles, parallel momentum, and energy in the banana regime. Previous work which only accounted for strong gradients in density and electric field [1] is extended by keeping the poloidally varying part of the electric potential and allowing the temperature gradient to have the same scale length as the density gradient.

Studying contributions from both passing particles and trapped particles in the banana regime, we find that the resulting transport is dominated by trapped particles. The self-consistent poloidally varying part of the electric potential contributes to trapping. Due to the nonlinear character of the equations, we find that for certain sources and boundary conditions there are no solutions. A neoclassical ion particle flux much larger than the electron particle flux is possible, but it requires parallel momentum input which could be provided through interaction with turbulence. We present example profiles and energy fluxes of a pedestal that are similar to those measured in real devices [2].

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References:

[1] P. J. Catto, F. I. Parra, et al., *Plasma Phys. Control. Fusion* **55**, 045009 (2013)
[2] E. Viezzer, T. Pütterich, et al., *Nucl. Fusion* **53**, 053005 (2013)