Kinetic Neoclassical Transport in the H-mode Pedestal

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Abstract. Multi-species kinetic neoclassical transport through the QH-mode pedestal and scrape-off layer on DIII-D is calculated using XGC0, a 5D full-f particle-in-cell drift-kinetic solver with self-consistent neutral recycling and sheath potentials. Quantitative agreement between the flux-driven simulation and the experimental electron density, impurity density and orthogonal measurements of impurity temperature and flow profiles is achieved by adding random-walk particle diffusion to the guiding-center drift motion. The radial electric field (E_r) that maintains ambipolar neoclassical transport across flux surfaces and to the wall is computed self-consistently on closed and open magnetic field lines, and is in excellent agreement with experiment. The E_r inside the separatrix is the unique solution that balances the outward flux of thermal tail deuterium ions against the outward neoclassical electron flux and inward pinch of impurity and colder deuterium ions. Particle transport in the pedestal is primarily due to anomalous transport, while the ion heat and momentum transport is primarily due to the neoclassical transport. The full-f treatment quantifies the non-Maxwellian energy distributions that describe a number of experimental observations in low-collisionallity pedestals on DIII-D, including intrinsic co-I_p parallel flows in the pedestal, ion temperature anisotropy and large impurity temperatures in the scrape-off layer.

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