

Abstract for an Invited Paper
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Drift-Kinetic Simulations of Neoclassical Transport¹

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A new δf Eulerian kinetic code NEO has been developed for numerical studies of neoclassical transport. NEO serves a dual role: in addition to its practical value as a tool for high-accuracy neoclassical calculations, NEO also functions as a stepping-stone (together with the nonlinear GK code GYRO) toward a full-F gyrokinetic code which integrates neoclassical transport and microturbulence. NEO solves a hierarchy of equations derived by expanding the drift-kinetic equation in powers of ρ_{*i} , the ratio of the ion gyroradius to system size, and thus provides a first-principles calculation of the neoclassical transport coefficients for general plasma shape directly from solution of the distribution function. NEO extends previous numerical studies by including the self-consistent coupling of electrons and multiple ion species, the calculation of the first-order electrostatic potential via coupling with the Poisson equation, and rapid toroidal rotation effects. Systematic calculations of the second-order particle and energy fluxes and first-order plasma flows, poloidal rotation, and bootstrap current and comparisons with analytical theories are presented for multispecies plasmas. The ambipolar relation, which requires complete cross-species collisional coupling, is confirmed, and finite mass-ratio corrections due to this collisional coupling are identified. Parameterized studies of the effects of shaping are performed, and the application of analytic formulae obtained for circular plasmas to shaped cases is discussed. Results using DIII-D experimental profiles and the effects of strong rotation are also presented. Finally, finite orbit width effects are studied via solution of the higher-order drift-kinetic equations, and the implications of non-local transport on the validity of the δf formulation for steep gradients in the H-mode edge are discussed.

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