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Long-wavelength limit of gyrokinetics in a turbulent tokamak and its intrinsic ambipolarity

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Recently, the electrostatic gyrokinetic Hamiltonian and change of coordinates have been computed to order ϵ^2 in general magnetic geometry. Here ϵ is the gyrokinetic expansion parameter, the gyroradius over the macroscopic scale length. Starting from these results, the long-wavelength limit of the gyrokinetic Fokker-Planck and quasineutrality equations is taken for tokamak geometry. Employing the set of equations derived in the present article, it is possible to calculate the long-wavelength components of the distribution functions and of the poloidal electric field to order ϵ^2. These higher-order pieces contain both neoclassical and turbulent contributions, and constitute one of the necessary ingredients (the other is given by the short-wavelength components up to second order) that will eventually enter a complete model for the radial transport of toroidal angular momentum in a tokamak in the low flow ordering. Finally, we provide an explicit and detailed proof that the system consisting of second-order gyrokinetic Fokker-Planck and quasineutrality equations leaves the long-wavelength radial electric field undetermined; that is, the turbulent tokamak is intrinsically ambipolar.

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