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Equivalent Higher-order Guiding-center Hamiltonian Theories

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Equivalent guiding-center Hamiltonian theories are constructed based on higher-order Lie-transform perturbation methods [1]. Higher-order guiding-center theories are distinguished on the basis of whether correction terms associated with magnetic-field nonuniformity appear either in the guiding-center symplectic (Poisson-bracket) structure, in the guiding-center Hamiltonian, or both. These theories are called equivalent [2]-[4] because they describe the same guiding-center magnetic-moment invariant.

Our work shows that the original guiding-center transformation derived by Littlejohn [5], which ignored first-order corrections in the guiding-center symplectic structure, is incomplete because it is unable to recover the standard guiding-center polarization [6]. We show how equivalent guiding-center Hamiltonian theories can be constructed (through Lagrangian, Hamiltonian, and Jacobian constraints) with the necessary corrections that yield the standard guiding-center polarization. Lastly, the conservation law of guiding-center toroidal canonical angular momentum in axisymmetric tokamak geometry is derived explicitly.

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