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Limitations of the Guiding Center Model for 3D Plasmas[1] LINDA SUGIYAMA, MIT — In 3D magnetic fields, guiding center (GC) approximations for the charged plasma dynamics that use the particle's guiding center to describe the motion, rather than particle position, encounter geometrical difficulties [1]. For small gyroradius $\epsilon = \rho_i/L < 1$. the fast gyration around the field lines is described in terms of a mathematical gyroangle, in local coordinates, and leads to a natural description in terms of an effective magnetic vector potential [2]. In a 2D with straight uniform field lines, such expansions in ϵ are exact to all orders. For general 3D fields, exact expansion to all orders requires good magnetic flux surfaces, zero magnetic torsion $\mathbf{b}\cdot\nabla\times\mathbf{b} = \mathbf{0}$, where $\mathbf{b} \equiv \mathbf{B}/\mathbf{B}$, and zero geodesic torsion τ_G on the flux surfaces. Most confined plasmas, however, have finite parallel current and finite torsion. GC expansions exist to first order in ϵ, but are nonuniform in velocity phase space. If the field possesses exact 2D symmetry, such as toroidal axisymmetry, the expansion can exist at higher order. Ordering the time derivative of the magnetic vector potential in Ohm's law to be small, equivalent to dropping the compressional and/or shear Alfvén waves, also introduces geometrical approximations.

[1] L.E. Sugiyama, submitted to Physics of Plasmas (2008).
[2] R.J. Littlejohn, *Phys. Fluids* **24** 1730 (1981).

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Linda Sugiyama
MIT

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