Abstract Submitted
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Global geometrical constraints on Lagrangian dynamics: guiding center plasma models in 3D* LINDA SUGIYAMA, M.I.T. — Hamiltonian and Lagrangian methods emphasize local dynamic relationships. In three or more dimensions, geometrical properties of vector fields may impose independent, global existence conditions. For strongly magnetized plasmas, the guiding center model of charged particle motion superimposes a rapid gyration around the magnetic field lines onto the smoother, gyroaveraged motion of a guiding center, ordered in small gyroradius $\epsilon = \rho_i/L$. Beyond first order, equations of motion can be formally derived by noncanonical Hamiltonian or Lagrangian methods[1]. In fully 3D magnetic fields, existence breaks down at second order[2] if the magnetic torsion $\tau = \hat{\mathbf{b}} \cdot \nabla \times \hat{\mathbf{b}}$ is nonzero, where $\hat{\mathbf{b}} = \mathbf{B}/\mathrm{B}$. No consistent set of locally orthogonal coordinates aligned to $\mathbf{B}$ at every point exists and the gyroangle is undefined (unlike in 2D fields, including toroidal axisymmetry). Ordering the magnetic field time-variation to be slow relative to the gyration introduces further geometrical approximations. The coordinate system existence condition generalizes to $n \geq 3$ dimensions, where it applies to questions such as to the connection of the large scale 4D space-time of general relativity to small scale, locally orthogonal theories, such as quantum phenomena.

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[1]R.J. Littlejohn, *J. Plasma Phys.* **29** 111 (1983); references therein.
[2]L.E. Sugiyama, *Phys. Plasmas* **15** 092112 (2008).

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