Symplectic integration of guiding-center dynamics in non-canonical coordinates

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Structure-preserving integration of guiding-center trajectories is an important ingredient for gyrokinetic particle methods with long-term conservation of invariants. Due to the inherently non-canonical formulation of the usual guiding-center Lagrangian, classical symplectic schemes cannot be directly applied there. For this reason recent developments have focused on variational rather than such symplectic integrators. In many cases it is however possible to formulate implicit equations relating canonical and non-canonical coordinates. Here, semi-implicit symplectic schemes relying on this idea will be discussed and their computational performance assessed in terms of preservation of invariants and geometric accuracy. For partitioned schemes such as symplectic Euler and Verlet methods the approach requires some conceptual re-interpretation of the role of internal stages that mix position and momentum at different times. The presented approach is applicable to stationary magnetic geometry where coordinate transformations can be efficiently pre-computed in a parallelized manner. In contrast to the magnetic geometry appearing in the transformation equations to canonical momenta, quantities in the Hamiltonian such as electrostatic fluctuations may explicitly depend on time in this approach.