GORILLA: Quasi-geometric integration of guiding-center orbits in piecewise linear toroidal fields

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A numerical integration method for guiding-center orbits of charged particles in toroidal fusion devices with three-dimensional field geometry as described in Ref. [1, 2] is presented. Here, high order interpolation of electromagnetic fields in space is replaced by a special linear interpolation, leading to locally linear Hamiltonian equations of motion with piecewise constant coefficients. This approach reduces computational effort and noise sensitivity while the conservation of total energy, magnetic moment and phase space volume is retained.

The underlying formulation treats motion in piecewise linear fields exactly and thus preserves the non-canonical symplectic form. The algorithm itself is only quasi-geometric due to a series expansion in the orbit parameter. For practical purposes an expansion to the fourth order retains geometric properties down to computer accuracy in typical examples.

When applied to collisionless guiding-center orbits in an axisymmetric tokamak and a realistic three-dimensional stellarator configuration, the method demonstrates correct long-term orbit dynamics. In Monte Carlo evaluation of transport coefficients, the computational efficiency of quasi-geometric integration is an order of magnitude higher than with a standard fourth order Runge-Kutta integrator.

A Fortran program with the name "**G**uiding-center **OR**bit **I**ntegration with **L**ocal **L**inearization **A**pproach" (GORILLA) is available on request and will soon be published as Open Source code on *GitHub*.

References

[1] M. Eder *et al.* 46th EPS Conf. on Plasma Physics, 2019, ECA Vol. 43C, P5.1100.

[2] M. Eder *et al.* under Review at Physics of Plasmas, arXiv:2007.08151