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P5.1100 Three-dimensional geometric integrator for charged particle orbits in toroidal fusion devices

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See the full abstract here http://ocs.ciemat.es/EPS2019ABS/pdf/P5.1100.pdf

A three-dimensional integrator for guiding center orbits of charged particles in toroidal fusion devices with 3D field geometry is described. The integrator uses a representation of the electromagnetic field by low order polynomials on a 3D tetrahedal grid and is intrinsically designed to preserve the total energy, perpendicular adiabatic invariant, and the phase space volume accurately for any grid size. Thus, it belongs to the class of geometric integrators. The integrator is designed for usage in Monte Carlo (MC) procedures to simulate particle distribution functions where a box counting method (calculation of dwell time within spatial cells) is used for the evaluation of macroscopic plasma parameters. Such a computation is needed, e.g., for the evaluation of plasma response currents and charges caused by external non-axisymmetric electromagnetic perturbations in tokamaks as well as for kinetic modeling of edge transport in devices with 3D field geometry. This geometric integrator is more efficient in evaluation of dwell times than a solution of guiding center equations with a high order adaptive ODE integrator, while keeping roughly the same speed for orbit computations, because dwell times and the particle's coordinates and velocities at boundaries of spatial cells are intrinsically available without additional efforts for tracing the intersections with cell boundaries. Similar to the 2D geometric integrator of Ref. [1] also the 3D geometric integrator is less sensitive to inaccurate representation of the electromagnetic field resulting from statistical noise in plasma response currents and charges computed by a MC method within a feedback loop. Artificial numerical diffusion which can arise in presence of perturbations is extensively discussed. It can be shown that the use of field aligned coordinates is beneficial and that such a diffusion scales inversely with the grid size and thus can be kept well below neoclassical values.

References

[1] S.V. Kasilov, A.M. Runov, W. Kernbichler, Computer Physics Communications 207, (2016), 282286

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