NUMERICAL PARTICLE HEATING AND DIFFUSION CORRELATED TO INTERPOLATION-INDUCED DIVERGENCE IN A MAGNETIZED PLASMA

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Numerical effects in particle-in-cell (PIC) simulations due to the interpolation of discrete magnetic fields are examined for the case of small $L_0(\nabla\cdot B)/B$ (where L_0 is the length of the system) and will be reported for large $L_0(\nabla\cdot B)/B$. Non-physical heating and diffusion across field lines is a concern in the simulation of many devices using magnetically-confined plasmas, e.g. magnetic-confinement fusion machines and sputtering magnetrons.

A classical axisymmetric magnetic-mirror configuration is used to investigate the effects of magnetic-field discretization. Sinusoidal fields are used to ensure truncation error exists to alternating orders in the numerical methods used. The magnetic field is discretized on a square grid, and linearly interpolated within the grid. The standard Runge-Kutta fifth-order accurate solver with a continuum magnetic field is used as a control method and compared to the PIC-standard leap-frog scheme. In a regime where space-charge effects are negligible, electric fields are neglected, reducing leap-frog to a Boris rotation wherein a linearized small-angle approximation is used[1].

Solutions from discrete- and continuous-fields are compared with particular interest in energy conservation and variations in particle-trajectory. For small $L_0(\nabla\cdot B)/B$ (max-norm of 0.06), numerical heating is found to be negligible. Numerical diffusion is measured as a deviation in the first-recurrence maps in an arbitrary plane. Confined-particle drifts map out circular trajectories in the first-recurrence map using either continuous or discrete fields. The average areas of the particle trajectories are compared and correlated to increasing numerical divergence in an exponential fit. For the purposes of numerical applications, the average area deviation in the first-recurrence map is also presented as a power fit against meshsize.

Results for large $L_0(\nabla\cdot B)/B$ will be presented as well as a study on resonance conditions associated with, for example, the gyration frequency and bounce period. The influence on the characteristics of numerical-diffusion correlation with respect to these resonances will be presented.

1. C.K. Birdsall, A.B. Langdon, *Plasma Physics via Computer Simulation*, IoP, 2005, pp. 58-63.

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