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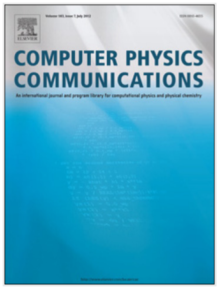

A new Particle-in-Cell method for modeling magnetized fluids

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A new Particle-in-Cell method for modeling magnetized fluids

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Abstract

We present a new Particle-in-Cell method for plasma simulations. This is based on the original algorithm of FLIP-MHD, which uses a Lagrangian formulation of the macroscopic equations. A finite-difference approximation of the equations of motion is solved on a fixed (non-moving) grid, while convection of the quantities is modeled with the support of Lagrangian particles. Interpolation with first-order b-splines is used to project the conserved quantities from particles to the grid and back. In this work, we introduce two modifications of the original scheme. A particle volume evolution procedure is adopted to reduce the computational error, based on the formulation used in the Material Point Method for computational mechanics. The additional step introduces little to none computational diffusion and turns out to efficiently suppress the so-called ringing instability, allowing the use of explicit time differencing. Furthermore, we eliminate the need for a Poisson solver in the magnetic field computation with the use of a vector potential in place of the particles' magnetic moment. The vector potential evolution is modeled with a moving grid and interpolated to the fixed grid points at each time step to obtain a solenoidal magnetic field. The method is tested with a number of standard hydrodynamic and magnetohydrodynamic tests to show the efficiency of the new approach. The results show good agreement with the

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