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Lattice Boltzmann formulation for Braginskii magnetohydrodynamics[1] PAUL DELLAR, University of Oxford —

We present a lattice Boltzmann formulation of the Braginskii magnetohydrodynamic equations that describe large-scale motions in strongly magnetised plasmas. Fluid quantities, density, velocity and stress, are represented by a finite set of distribution functions associated with particles moving on a square or cubic lattice. Equilibrium distributions are constructed from Hermite moment expansions, so slowly varying solutions of the discrete kinetic equation exactly satisfy the Navier–Stokes or MHD momentum equations. Electromagnetic quantities are represented by a second kinetic equation for a set of vector-valued distribution functions. Maxwell's equations and the resistive MHD induction equation may be recovered from slowly varying solutions using different scalings. The resulting algorithm, comprising only local operations at grid points and data copying between adjacent points, readily lends itself to large-scale parallel computations. We modify the collision operator to apply different relaxation times to components of the stress parallel and perpendicular to the local magnetic field, simulating a form of the Braginskii MHD equations encountered in astrophysics. Large shears develop in simulations where the fluid velocity perpendicular to the field lines reverses.

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