2013

A Time-Implicit Algorithm for Solving the Vlasov–Poisson Equation

Bradley Allan Shadwick
University of Nebraska-Lincoln, shadwick@unl.edu

M. Carrie
University of Nebraska-Lincoln

Plasma Science (ICOPS), 2013 Abstracts IEEE International Conference on
Year: 2013
Pages: 1 - 1, DOI: 10.1109/PLASMA.2013.6634925

A Time-Implicit Algorithm for Solving the Vlasov–Poisson Equation*

B. A. Shadwick and M. Carrié
Department of Physics & Astronomy
University of Nebraska-Lincoln
Lincoln, NE 68588-0299

We present a new time-implicit algorithm solving for the Vlasov–Poisson equation in one phase-space dimension. This method exhibits superior conservation properties; the two lowest-order Casimir invariants (particle number and integral of f^2) are exactly conserved while the error in energy remains bounded. We demonstrate this algorithm for both the nonrelativistic and relativistic Vlasov equation. (Our interest in the relativistic system is motivated by our ultimate goal of applying this algorithm to the Maxwell–Vlasov system to study intense laser-plasma interactions.) A straightforward implementation of the implicit algorithm requires solving a large nonlinear system of equations at each time step. Operator splitting can be used to convert the nonlinear system to a collection of independent tri-diagonal linear systems that can be efficiently solved using the Thomas method. We present two versions of the algorithm, one based on the operator splitting method and one using a Newton-Krylov method to solve the nonlinear system. We consider a number of benchmark examples with both the full system as well as the linearized equations. We discuss the relative merits of the two implementations.

* Department of Energy under Contract Nos. DE-FG02-08ER55000 and DE-SC0008382 and by the National Science Foundation under Contract No. PHY-1104683.