Structure preserving algorithms for the Vlasov equation and their implementation on modern computer systems

Lukas Einkemmer[1]

[1]*Numerical Analysis Group, Universität Innsbruck, Austria*

We consider the numerical solution of the Vlasov-Poisson and the Vlasov-Maxwell equations within a semi-Lagrangian approach. To that end we first use a time splitting scheme in order to decompose the Vlasov equation into a sequence of lower dimensional problems. In this setting we show how to extend the classic splitting of Cheng & Knorr to the Vlasov-Maxwell system while still maintaining its favorable properties with respect to energy conservation. In addition, we introduce a modification of this splitting scheme that renders it efficient in the classic limit regime. The resulting lower dimensional advection equations are then solved using the semi-Lagrangian discontinuous Galerkin method. This method is a local numerical scheme (i.e. no global communication is required) that respects the H-theorem and decreases the L^2 norm (which is reasonable from a physical point of view but does not hold true for spline interpolation, for example). We then discuss the implementation of the described numerical method on both traditional clusters as well as on graphic processing units (GPUs) and on the Xeon Phi. We show that by choosing the degrees of freedom as coefficients in a Legendre expansion, a mixed precision implementation can result in a significant increase in performance while still preserving mass to double precision accuracy. This talk is based on [1]–[4].

References

[1] L. Einkemmer, A mixed precision semi-Lagrangian algorithm and its performance on accelerators. To appear in High Performance Computing and Simulation (HPCS), 2016 International Conference on

[2] N. Crouseilles, L. Einkemmer, E. Faou, A Hamiltonian splitting for the Vlasov-Maxwell system, J. Comput. Phys. 283 (2015)

[3] N. Crouseilles, L. Einkemmer, E. Faou, An asymptotic preserving scheme for the relativistic Vlasov-Maxwell equations in the classical limit, arXiv:1602.09062

[4] L. Einkemmer, On the geometric properties of the semi-Lagrangian discontinuous Galerkin scheme for the Vlasov-Poisson equation. arXiv:1601.02280