Solving the Vlasov equation on modern computer architectures: algorithms and efficient implementation

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Graphic processing units (GPUs) significantly exceed more traditional CPU based systems both in terms of floating point performance but also with respect to memory bandwidth. Thus, they are recognized as a promising platform for conducting scientific computations. However, to fully exploit this computer architecture very fine grained parallelism is required and memory access should be as contiguous as possible. In addition, GPUs do have relatively small caches compared to CPU based systems.

All of these constraints pose significant challenges for semi-Lagrangian Vlasov simulation as many of the commonly used algorithms do not map very well to modern hardware. Our goal in this talk is to show that semi-Lagrangian Vlasov simulation can be conduced efficiently on GPU based platforms. To accomplish this we use the local and conservative semi-Lagrangian discontinuous Galerkin scheme implemented in the `C++` SLDG code. We will show performance comparisons that demonstrate that a single GPU node is able to eclipse the performance of a small cluster. The semi-Lagrangian discontinuous Galerkin scheme is also well suited for mixed precision computations, which lately have received renewed interest.

One common theme of this talk will be to explore the interplay between designing algorithms and running them efficiently on modern computer hardware. In this context we also explore how we evaluate the performance of a numerical algorithm far away from the asymptotic regime, which is a fairly typical situation for the plasma physics simulations we have in mind. We also note that many of the algorithmic and implementation optimizations also benefit, albeit to a lesser extend, traditional CPU based systems.

References

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