Energy Conservation in Multiscale Kinetic Simulations: Semi-implicit versus Implicit approaches


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Energy in the solar system is constantly being converted from one form to another. Often these processes take the form of dramatic events such as solar eruptions or geomagnetic storms with important societal impacts. Understanding energy conversion and magnetic storms is one of the grand challenges facing science and poses a great cultural and scientific puzzle. We present a new energy conserving particle in cell method that allows us to treat electrons and ions fully kinetically using computational particles, at a reasonable computational cost. The advantage of the method presented is that it is semi-implicit: this avoids the complexity and costs of the fully implicit method and goes beyond the severe resolution limitations of explicit methods. The new Energy Conserving Semi Implicit Method (ECSIM) [1, 2] joins the advantages of semi-implicit methods with the energy conservation properties of fully implicit methods [3].

In this work, we compare the new ECSIM method with the fully implicit PIC method. While the ECSIM does not require any non-linear iteration, the fully implicit method does. We test different types of preconditioners to lower the cost of the Newton and Krylov iterations needed for achieving convergence in the non-linear solvers.

References

