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A Fully Spectral Filtered Vlasov-Maxwell Electromagnetic Kinetic Simulations

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Introduction

Many phenomena in astrophysical, solar and fusion plasmas require a kinetic rather than a fluid description to understand physical processes occurring at very small spatial scales and faster time scales. The fundamental quantity describing the physics of these processes is the particle velocity distribution function in phase-space $f(\mathbf{x}, \mathbf{v}, t)$ that determines the number density, bulk velocity, and thermal pressure of particles at position $\mathbf{x}$ moving with velocity $\mathbf{v}$ at time t. Numerical computations of the evolution of the distribution function via the vlasov equation in its six-dimensional phase-space and time are thus very demanding on computational resources.

Filamentation and recurrence lead to numerical difficulties in Vlasov simulations after times which are inversely proportional to the velocity resolution of the simulation. Because of these numerical problems, many researchers moved away from Vlasov simulation in favour of the particle-in-cell (PIC) technique. Recent methods have been implemented to mitigate these problems in numerical Vlasov simulations by introducing a filtered Vlasov phase-space distribution, where the relevant equations are Fourier transformed in both the spatial position and velocity variables [1–3]. However, all the previous filtered spectral Vlasov simulations were limited to electrostatic Vlasov-Poisson simulations. In this work, we focus on extending the filter spectral Vlasov simulations to the full electromagnetic Vlasov-Maxwell domain implementing the methods by which both the filamentation and recurrence problems are removed.

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References

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