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A Deep Dive into the Distribution Function: Understanding Phase Space Dynamics Using Continuum Vlasov-Maxwell Simulations[1]

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In collisionless and weakly collisional plasmas, the particle distribution function is a rich tapestry of the underlying physics. However, actually leveraging the particle distribution function to understand the dynamics of a weakly collisional plasma is challenging. The equation system of relevance, the Vlasov-Maxwell system of equations, is difficult to numerically integrate, and traditional methods such as the particle-in-cell method introduce counting noise into the distribution function. Motivated by the physics contained in the distribution function, we have implemented a novel continuum Vlasov-Maxwell method in the Gkeyll simulation framework. I will present results of simulations of collisionless shocks which utilize both the high fidelity representation of the particle distribution function provided to us by a continuum method, and modern phase space diagnostics such as the field-particle correlation, to ascertain the details of the energy exchange via these collisionless shocks. These results, in addition to providing insight into the phase space structure observed in the ever higher quality distribution function data from spacecraft missions such as the Magnetospheric Multiscale mission, highlight the strength of this complementary, noise-free, approach to kinetic simulations.

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