Noiseless Vlasov-Poisson simulations with linearly transformed particles

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Abstract

In this talk we introduce a deterministic particle-in-cell (PIC) method with linear transformations of the particles that help remove the noise traditionally observed with particle schemes. On a formal level, transforming the particles is justified by a first order expansion of the local characteristic flow. Because it is necessary to periodically remap the particles on a regular grid to avoid excessively deforming their shapes in practice, the method can be seen as a development of the Forward Semi-Lagrangian (FSL) scheme introduced by Denavit in 1972. However, with this new scheme the numerical solutions are shown to converge towards the exact ones with no oscillations, even without remapping. Deforming the particles can thus be seen as a way to significantly lower the remapping frequency needed in the FSL schemes. As a result, the numerical diffusion is also significantly less. Numerical 1d1v simulations involving benchmark test cases and halo formation in an initially mismatched thermal sheet beam will be shown, that demonstrate some advantages of our Linearly-Transformed PIC (LTPIC) scheme over the classical PIC and FSL methods. The choice of an appropriate charge deposition scheme will also be discussed.