Sparse grid approach to accelerate the Particle-In-Cell method

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In this presentation, modelisation of kinetic plasmas with Vlasov-Poisson equations will be taken up in the case of the widely spread Particle-In-Cell method. This method consists in a coupling between a particle approach for the Vlasov equation and a mesh based method for the computation of the self-consistent field using Poisson's equation. Including simplicity, ease of parallelization and robustness, Particle-In-Cell schemes still contain a main drawback with the statistical error associated to the particle noise, depending on the average number of particle per cell and leading to a complexity that grows exponentially with the dimension. Though the idea of sparse grids has been studied extensively in applied mathematics for years, Particle-In-Cell's application of the method is only at its beginnings. The use of sparse grids in the Particle-In-Cell method, through the so-called combination technique where a function is approximated on different coarser grids, allows to reduce the particle noise, thanks to the larger cells of the grids, and thus reduces the high run times of simulation.

The idea of the presentation is to first introduce the sparse grids in the context of Particle-In-Cell and explicit the method ; then discuss some convergence and conservativity properties of the scheme ; propose a few alternatives in order to reduce the error introduced by either the particles or the grid. Eventually a comparison between the different methods with some classical test cases of plasma physics will be provided.

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