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Noise and error analysis and optimization in particle-based kinetic plasma simulations[1] EVSTATI EVSTATIEV, Sandia National Laboratories, JOHN FINN, Tibbar Plasma Technologies, BRADLEY SHADWICK, University of Nebraska-Lincoln, NICK HENGARTNER, Los Alamos National Laboratories — In high fidelity kinetic particle simulations numerical noise and error are of primary concern. We address minimizing that error in 1D electrostatic models. We use kernel density estimation for continuous x, with separate kernel shape and width W. The covariance matrix of the noise is computed. We note the presence of constant negative entries related to fixing the number of particles. We study the effect of these correlations on the electric field E(x) computed by Gausss law and find an analogy to the Ornstein-Uhlenbeck bridge, leading to a covariance matrix that is reduced relative to a Brownian process. For non-constant density we analyze the total error in terms of bias-variance optimization (BVO). We repeat the analysis on a grid, where the charge deposition rule is determined by a particle shape. An important property is the exact preservation of charge on the grid to ensure the equality of E(x) at the ends. We find that a particle shape satisfying a sum rule (SR) leads to charge conservation. If the particle shape is the convolution of a kernel with a second kernel (or finite element) satisfying SR, the particle shape obeys SR. This also holds for kernels of width not a multiple of the grid spacing. We do BVO numerically as a function of W, finding agreement with theory.

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