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Multi-level Monte Carlo Methods for Efficient Simulation of Coulomb Collisions[1]

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We discuss the use of multi-level Monte Carlo (MLMC) schemes - originally introduced by Giles for financial applications - for the efficient simulation of Coulomb collisions in the Fokker-Planck limit. The scheme is based on a Langevin treatment of collisions, and reduces the computational cost of achieving a RMS error scaling as ε from $O\left(\varepsilon^{-3}\right)$ - for standard Langevin methods and binary collision algorithms - to the theoretically optimal scaling $O\left(\varepsilon^{-2}\right)$ for the Milstein discretization, and to $O\left(\varepsilon^{-2}(\log \varepsilon)^2\right)$ with the simpler Euler-Maruyama discretization. In practice, this speeds up simulation by factors up to 100. We summarize standard MLMC schemes, describe some tricks for achieving the optimal scaling, present results from a test problem, and discuss the method's range of applicability.