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Brownian Dynamics without Green's Functions

Aleksandar Donev[1]

[1] Affiliation: Courant Institute of Mathematical Sciences, New York University, New York, NY 10012
donev@courant.nyu.edu, http://cims.nyu.edu/~donev/

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Brownian and Stokesian dynamics are widely used methods for simulating the dynamics of colloidal or polymeric fluids when thermal fluctuations (Brownian motion) is important. One notable downside of these methods is that they rely on analytically-computed Green's functions for Stokes flow, which is particularly challenging in non-trivial geometries. Another difficulty encountered in traditional Brownian dynamics is computing the stochastic noise terms. We present an alternative approach which uses a fluctuating fluid solver to compute the required actions of the Green's functions "on the fly". The particles are represented using a minimally-resolved "blob" immersed boundary technique. Our method correctly generates both the deterministic and stochastic dynamics using a single steady Stokes solver. This allows us to easily change the boundary conditions, including cases in which the concentration of the chemical reactants affects the fluid flow via osmo-phoretic effects. Furthermore, temporal evolution (unsteadiness) and even nonlinearities can easily be added, and the resolution can be refined locally using adaptive mesh refinement techniques.