# Particle Laden Flows: Stochastic Models and Efficient Algorithms

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**Abstract:**
The conjugate transport occurring between solid particles and a dynamic carrier fluid leads to complex and multi-scale physics. Consequently, the simulation of particle-laden flows ranges from model-free methods (e.g., particle-resolved direct numerical simulation; PR–DNS) to statistical methods that rely heavily on models (e.g., Eulerian–Eulerian methods; EE). Within the range of simulation scales, Eulerian–Lagrangian (EL) methods have proven to be a valuable tool for modeling strongly-coupled particle-laden flows. However, existing drag force closures developed for EL methods typically capture the mean drag force experienced by an assembly of particles.
Therefore, the distribution of drag forces, arising from sub-grid, neighbor-induced, fluid disturbances, is generally ignored, with implications on the accuracy in quantitatively predicting higher-order moments (granular temperature and dispersion). Here, we examine a force Langevin (FL) model that treats neighbor-induced drag fluctuations as a stochastic force. Including the FL model within an EL framework leads to dramatically improved predictions for the evolution and sustainment of granular temperature over a wide range of Reynolds numbers and solids volume fractions, when compared to PR–DNS of freely-evolving homogeneous suspensions. Furthermore, the FL paradigm permits analytical solutions for the hydrodynamic sources and sinks to granular temperature in moderately dense suspensions of elastic particles at finite Reynolds numbers.
Agreement between said solutions and PR–DNS benchmark data is demonstrated and motivation for a general theory from gas–solid to bubbly flows is considered. Finally, a multi-grid approach is presented for constructing linked neighbor lists, used to compute pairwise collision forces between particles. Traditional neighbor list algorithms generally involve particle-in-cell binning with a single grid. Unfortunately, for polydisperse solids, the single-grid approach leads to a bloated neighbor list that provides considerable computational overhead. The multi-grid neighbor search algorithm is implemented within the AMReX library, a block-structured adaptive mesh refinement software, and its scaling on CPU/GPU is assessed via EL simulations with MFiX-EXA, an exascale multiphase flow solver.

## Biography:

Dr. Aaron M. Lattanzi is a project scientist in the Applied Mathematics and Computational Research Division at Lawrence Berkeley National Laboratory (LBNL). Aaron contributes to a variety of projects but primarily serves as a core developer for the Energy Research and Forcasting (ERF) software, a next-generation atmospheric modeling code. Prior to joining LBNL, Aaron held a postdoctoral appointment in the department of Mechanical Engineering at the University of Michigan (supervised by Prof. Jesse Capecelatro). Additionally, before joining UMich, Aaron enjoyed a yearlong postdoctoral appointment at the National Renewable Energy Laboratory in Golden, Colorado. Aaron's PhD was earned in 2018 from the department of Chemical and Biological Engineering at the University of Colorado (supervised by Prof. Christine Hrenya) and his undergraduate studies were completed at the University of Washington in 2013.

***This seminar counts towards the ME 600 seminar requirement for Mechanical Engineering graduate students.**
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