# THREE-DIMENSIONAL COUPLING OF PARTICLE MOTION AND FLUID FLOW USING THE DISCRETE ELEMENT AND LATTICE BOLTZMANN METHODS

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The modeling of problems such as bed fluidization in industrial applications, sedimentation in particle-laden fluids, or sand flows generated by pumping in oil reservoirs demands the resolution of coupled particle-fluid physics. Researchers have recently had success in modeling these coupled systems at the particle scale in two dimensions by using a combination of the discrete element method (DEM) and the lattice Boltzmann method (LB) [1,2]. The DEM for modeling the micro-mechanics of granular systems is based on the resolution of contact mechanics and momentum conservation laws on a particle-by-particle basis. The LB method for computational fluid dynamics is based on the collision and streaming of fluid distributions at discrete points on a lattice covering the domain, which recovers the incompressible Navier Stokes equations under certain numerical constraints. The coupling of these two highly efficient solvers is accomplished by using a modified immersed boundary condition in the lattice Boltzmann method with an exchange of momentum at the fluid nodes covered by the solids. Both the DEM and the LB method have the advantage that they scale nearly linearly in computational effort for large systems of particle-laden fluids, while still capturing the relevant physics for direct simulation.

We present an extension to three dimensions of the DEM-LB coupling described above. The particular implementation of the LB method used is the D3Q19 lattice with the Bhatnagar-Gross-Krook approximation [3]. In our DEM implementation we adopt the usual assumptions that the contact forces are linearly dependant on contact overlap and that energy losses due to deformation can be represented by a linear dashpot at each contact point. These assumptions imply that particle deformations are small.

We have developed a three-dimensional visualization platform in order to understand the complicated behavior of the coupled particle-fluid systems, and have used this platform to verify our model. We benchmark the model by comparing the settling dynamics of particles in several simulations to previously published results.

**References**

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