Numerical modelling of fluid-grains interactions

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Abstract

Despite their very broad range of applications, fluid-grain interactions remain poorly understood. These interactions control the physical properties of fluid-filled granular media in many industrial processes and environmental systems such as fluid-grain mixtures, fluidized beds, agglomeration processes, suspensions, saturated soils, landslides, etc. Simplified approaches have been developed to take into account the effect of a suspending or wetting fluid on the solid phase but accurate simulations require a high resolution of the liquid phase and a two-way coupling of particle dynamics with stepwise solver of Navier-Stokes equations for the fluid phase.
In this talk, we focus on the Lattice Boltzmann Method (LBM) and its coupling with the Discrete Element Method (DEM). The LBM evolved from the Lattice-Gas Cellular Automata, a statistical model based on the kinetic theory of gases, which simulates the fluids as pseudo-particles at discrete points in space. In LBM the fluid variables are partial probability functions of finding fluid particles moving from site to site on a lattice and the classical fluid-dynamics variables are upscaled by averaging the partial distribution functions at each node. This statistical-physics based description has proved to be vey robust and versatile in many fluid dynamics applications. Among good qualities of LBM, one can cite the simplicity of its implementation and handling complex boundary conditions, its excellent performance in parallel computing and the possibility to simulate complex fluids with multiple phases and components.

In this talk, we briefly recall the principles of LBM and we give three examples in which fluid-grains interactions are driving the behaviour of granular materials: 1) the shear behaviour of particles immersed in a viscous fluid, 2) the initiation of avalanches in tilted a granular beds, 3) the liquid distribution in unsaturated granular media.

Keywords: Fluid, Grain coupling, Lattice Boltzmann Method

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