Grain-resolved simulations of particle-laden flows with a coupled lattice Boltzmann - discrete element method

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ABSTRACT

Particle-laden flows are encountered in various fields of civil and environmental engineering where e.g. the effect of sediment transport on dune formation and river morphology is studied. In order to improve the existing predictive models, a better understanding of the mechanisms involved in the sediment transport is crucial. In recent years, engineers and sedimentologists have become increasingly interested in applying massively parallel simulations to investigate such systems numerically. Compared to laboratory experiments, these direct numerical simulations of particulate flows allow for extensive parameter studies and provide detailed insight into the physical processes.

In this talk, we will focus on simulations with geometrically fully resolved particles that enable accurate predictions from first principles. The lattice Boltzmann method (LBM) with a multiple-relaxation-time collision operator is used to represent the fluid dynamics. Interactions between particles are accounted for by the discrete element method (DEM) with additional lubrication forces [1]. The fluid-particle coupling is based on the momentum transfer between the particulate and the fluid phase [2]. An efficient and scalable implementation of our approach within the WALBERLA framework [3] enables large-scale simulations of sedimentary flows featuring several thousand particles interacting with the fluid flow.

We will show different test scenarios that involve submerged particle-wall collisions in order to validate our method. This method is then utilized to study transport phenomena in flows over dense sediment beds [4]. By extending the work of Vowinckel *et al.* [5], we aim to enhance the understanding of mechanisms leading to incipient motion and erosion events of individual particles. Based on our simulation results, more accurate erosion models can be formulated and then be used to predict the evolution of riverbeds.

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