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Coupled LBM-DEM model and its application to droplet impact on deformable porous media

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The dynamic behavior of multiphase flow in gas-solid-liquid mixture systems plays an important role in various applications of petroleum industry, biochemical processing, chemical and metallurgical industry, food technology, water treatment, and sub-seabed CO2 storage and its understanding can provide insights in various phenomena like rain deposition, landslides and degradation of heritage artefacts and buildings.

In this paper, we propose a numerical model to simulate such problems, coupling lattice Boltzmann and discrete element methods (LBM-DEM). A cascaded LBM is used to simulate the liquid-gas flow field using a pseudopotential interaction model for describing the liquid-gas multiphase behaviour. A classical DEM resorting to fictitious overlaps between the particles is used to simulate the multi-particle system. A multiphase fluid-solid two-way coupling algorithm between LBM and DEM is constructed. The model is validated by three benchmarks: (i) single cylinder particle sedimentation, (ii) single floating particle on a liquid-gas interface and (iii) self-assembly of three particles on a liquid-gas interface. Our simulations agree well with theoretical or numerical results reported in the literature.

Our proposed model is applied to simulate droplet impact on deformable granular porous media at pore scale. The dynamic droplet spreading process, the deformation of the porous media (composed of up to 1000 solid particles), as well as the invasion of the liquid into the pores within a wide range of impact Weber number are well captured. The droplet spreading dynamics on particles is compared to droplet impact on a flat solid surface. A scaling analysis is conducted to unify the two impact problems taking into account different fluid properties (viscosity), fluid-solid interaction (surface tension) and deformability of the substrate. An energy analysis allows determining the different mechanisms at play, showing the effects of kinetic and potential energy, surface energy and viscous dissipation.

Participation

In-Person

References

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