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Simulation of wetting regimes in a 2D granular packing

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In wet granular materials, the liquid – in the form of clusters that bind the grains together or in the form of thin adsorbed phase – plays a key role in the rheological properties. Manufacture of pharmaceutical pills, shear strength of wet and coarse soils, triggering of landslides or pollution transport in zones above water tables are some examples.

The talk is concerned with a numerical analysis of liquid distribution within a 2D granular packing. The thermodynamics of phase change is based on Carnahan-Starling's equation-of-state from which the interactions between liquid, gas and solid (grains) are derived using nonlocal potentials in the framework of Multiphase Lattice Boltzmann method. These potentials are calculated on a regular mesh between the fluid particles and neighboring lattice nodes that control the surface tension and the contact angle between fluid and solid.

Injecting, slowly and homogeneously, vapor that condense in-between the grains and in the liquid phase, increases the saturation degree. A flood-fill algorithm is used to identify the liquid clusters and to determine their volume and connectivity with grains. The latter feature provides rich information that is analyzed from the point of view of the liquid phase and also of the grains. The pressures of the clusters are analyzed as a function of liquid content. This gives access to the global liquid-retention curve as well as the forces acting on each grain. By integrating these forces, we compute the negative pressure in the sample due to capillary forces and hence the capillary cohesion of the material. The plot of cohesive strength as a function of saturation degree reveals four different states reflecting the connectivity of the liquid phase and local grain environments. We find that the liquid phase undergoes a percolation transition for a liquid content well below full saturation. Interestingly, the cohesive strength has its peak value below this transition, dividing thus the funicular regime into an ascending cohesion regime followed by a descending cohesion in the late funicular regime.