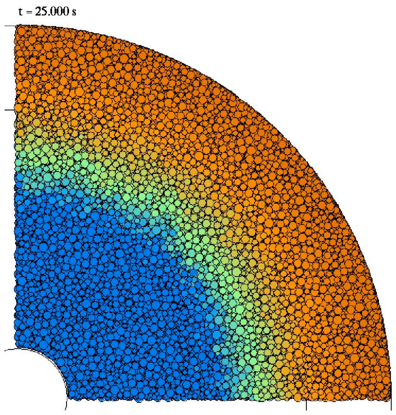
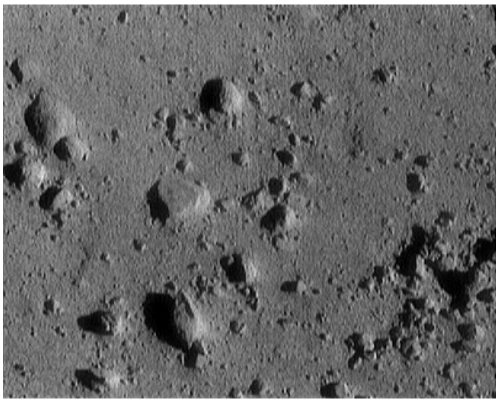
Call for a Joint Master thesis:

Cohesive powder (Regolith) properties by DEM simulations

Regolith is a layer of loose, heterogeneous material covering solid rock objects in space. It includes dust, soil, broken rock, and other related materials and is present on Earth, the Moon, Mars, some asteroids, and other terrestrial planets and moons. This material displays strong van der Waals adhesion as the major source of its strongly cohesive behavior under micro-gravity conditions.





(Left) Ring-shear cell (1/4) DEM simulation to measure the shear-stress-strain relation of cohesive powders;
(Right) Asteroid surface with coarse regolith. Taken from just 250 m above the surface of asteroid Eros as the NEAR Shoemaker spacecraft was landing, this image shows an area that is only 12 m across, resolution ~1cm.

Lander and sampling tools for sample return missions on small bodies of the Solar System (asteroids, comets) are getting into focus of the big space agencies. DLR is presently involved in the Rosetta Lander Philae, in MASCOT (a lander for the Japanese Hayabusa-2 mission, launch 2014/2015, landing 2018/2019) and in proposals for an ESA Asteroid mission (Marco-Polo R). A sampling device for a comet sample return mission is being developed at DLR. In November 2014, ESA's cornerstone mission Rosetta will deliver the comet lander Philae (lead: DLR and CNES) to the surface of comet 67P/Churyumov-Gerasimenko. From this event, measurements of the mechanical properties of the comet "soil" will be available as "ground truth" for verification/validation and calibration of numerical and theoretical models.

For the technical design of landing systems and sampling mechanisms it is very important to have models for the interaction of these systems with the regolith, which usually covers the surface of small bodies. Very little is known about the mechanical properties of comet material, while lunar regolith has been characterized in detail For asteroids, at least data about the typical grain sizes can be given and the bulk material can often be related to meteoritic analogs. The surface of asteroids can thus be imagined as polydisperse granular matter of high porosity, composed of angular silicate or carbonaceous chondrite particles with sizes in the micrometer to decimeter range. Microgravity conditions lead to significant differences from the mechanical properties of analogs under Earth gravity: the „overburden pressure" practically vanishes, and (van der Waals) cohesion forces dominate even for large grains [Scheeres et al., 2010]. Due to the absence of humidity and even an atmosphere, liquid bridge cohesion and fluidization effects are missing.

It is the aim of this joint project to develop „best estimates“ / „engineering ranges“ for the parameters of mesoscopic mechanical interaction models [Luding, 2008] for asteroid- and comet-surface materials.
Goal of the work is to set up a particle simulation model, calibrate/verify it with existing laboratory measurements and to model/predict the material response by many-particle simulations.

The thesis will consist of setting up an existing DEM (discrete element method, i.e. particle simulation) software from the University of Twente (S.Luding) on a PC workstation under LINUX, formulating the problem in a way solvable by the software, assigning input parameters / parameter ranges to the simulations, running, evaluating and analysing the simulations. Experience with C(++) and a good understanding of mechanics and numerical methods is required.

Extended stays at the University of Twente (NL) and at DLR Cologne (Germany) are necessary. A Master promotor at the home university would be most practical. A contract at DLR Cologne, RB-MUSC is foreseen.

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Literature:

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