DY 13: Granular Physics 3 - organized by Matthias Sperl (Köln)

Time: Monday 15:00–17:20 Location: DYc

DY 13.1 Mon 15:00 DYc

Monitoring granular drag with non-invasive particle tracking techniques — •Kai Huang[1,2], Jinchen Zhao[1], Chen Lyu[1], Valentin Dichtl[2], and Simeon Voelkel[2] — [1]Institute of Applied Physical Sciences and Engineering, Division of Natural and Applied Sciences, Duke Kunshan University, No. 8 Duke Avenue, Kunshan, Jiangsu, China 215316 — [2]Experimentalphysik V, Universität Bayreuth, 95440 Bayreuth, Germany

Considering granular materials as a complex fluid with a finite yield stress, an object moving inside has to locally unjam and mobilize the surrounding particles in order to step forward. Consequently, granular drag depends strongly on the local rheological behavior and it is essential to have an 'insider' view on granular dynamics. Experimentally, this is achieved using microwave radar and embedded IMU sensor techniques. Our results are in align with discrete element simulations equipped with coarse-graining techniques, which provide additional information on response of the granular bed. Our results of the intruder dynamics are in congruent with existing phenomenological model on granular drag. Interestingly, we find that the macroscopic profiles of the granular bed ahead of the intruder decays exponentially in the co-moving system of the intruder, giving rise to a characteristic length scale on the order of intruder size. Stepping further, we explore the influence of gravity on granular drag by means of microgravity environment in order to shed light on challenges arising from space exploration.

DY 13.2 Mon 15:20 DYc

Granular Rheology from First Principles — •Till Kranz[1], Olfa Lopez[2], Olivier Coquand[2], and Matthias Sperl[2,1] — [1]Institut für Theoretische Physik, Uni Köln — [2]Institut für Materialphysik im Weltraum, DLR Köln

We have recently demonstrated that the *Granular Integration Through Transients* (GITT) formalism allows to derive a constitutive equation for the shear stress σ as a function of the shear rate $\dot{\gamma}$ for arbitrary shear rates and high densities [1] of a granular fluid. Here we extend the formalism to derive a constitutive equation for the pressure $p(\dot{\gamma})$. This allows us to discuss flow curves at constant pressure and the *effective friction* $\mu = \sigma/p$. The phenomenological $\mu(I)$ rheology [2] relates the friction μ to the dimensionless inertial number I. We will discuss the relation between the GITT expressions and $\mu(I)$ rheology. In addition, we will present experimental stress measurements on fluidised glass beads covering several orders of magnitude in shear rate and displaying all the rheologigcal regimes predicted by GITT, namely, Newtonian rheology, as well as shear thinning and shear thickening behaviour.

[1] W. T. Kranz, F. Frahsa, A. Zippelius, M. Fuchs and M. Sperl, PRL **121**, 148002 (2018); PRF **5** 024305 (2020)
[2] GDR Midi, EPJ E **14**, 341 (2004)

DY 13.3 Mon 15:40 DYc

Aeolian structure formation in a laboratory wind tunnel — •Merve Seckin[1], Philip Born[1], and Matthias Sperl[1,2] — [1]Institut für Materialphysik im Weltraum, DLR Köln — [2]Institut für Theoretische Physik, Uni Köln

Aeolian transport causes structure formation in beds of granular particles. The length scale of structures formed by aeolian transport is fundamentally connected to the saturation length of the particle flux. Achieving structures on length scales suitable for laboratory experiments by minimizing this saturation length is challenging, but would allow testing and calibrating models of aeolian transport.

Here we show results obtained with very fine particles with an additional surface treatment to minimize cohesion. Saturation lengths of a centimeter can be obtained with this particle system. Consequently, we can show that self-initiated and sustained structure formation from particle beds by aeolian transport is possible at ambient conditions in a benchtop wind tunnel. Barchan-like structures emerge from flat particle beds and from particles heaps, which migrate downwind even without particle influx. We compare the experimental results with the existing theory and discuss open questions.

DY 13.4 Mon 16:00 DYc

Numerical investigation of the rheology of elongated particles — •Ellák Somfai[1], Dániel Nagy[1], Philippe Claudin[2], and Tamás Börzsönyi[1] — [1]Institute for Solid State Physics and Optics, Wigner Research Centre for Physics, Budapest, Hungary — [2]Physique et Mécanique des Milieux Hétérogènes, PMMH UMR 7636 CNRS, ESPCI Paris, PSL University Sorbonne Université, Université de Paris, Paris, France

We performed discrete element model simulations to investigate the rheology of a realistic 3-dimensional frictional granular material consisting of elongated particles. Such systems develop orientational ordering when exposed to shear flow. The degree of this ordering depends on the interparticle friction and particle elongation in a nontrivial manner. Namely, the shear induced orientational ordering is in principle increasing with particle elongation, but the characteristics of collisional and frictional interactions between neighbours (which hinder each others rotation) changes with the interparticle friction coefficient. We measured how key rheological quantities, including effective friction and normal stress differences depend on these two key parameters. We found that the aspect ratio dependence of the effective friction is nonmonotonic not only for frictionless particles as we saw earlier, but also for frictional particles up to interparticle friction coefficient $\mu_p \lesssim 0.4$, – a range already relevant for every day materials. For higher μ_p the effective friction is monotonically increasing. We can explain the microscopic origins of both the non-monotonic behaviour for small and intermediate μ_p and the monotonic one for large μ_p.

DY 13.5 Mon 16:20 DYc

Migrating shear bands in shaken granular matter — Joelle Claussen[1], Stefan Gerth[1], Jonathan E. Kollmer[2,3,4], Thorsten Pöschel[3], Michael Salamon[1], •Matthias Schröter[3,5], Tara Shreve[3,6], and Norman Uhlmann[1] — [1]Fraunhofer-Entwicklungszentrum Röntgentechnik, Flugplatzstr. 75, 90768 Fürth, Germany — [2]Experimentelle Astrophysik, Universität Duisburg-Essen, Lotharstr. 1-21, 47057 Duisburg, Germany — [3]Institute for Multiscale Simulation of Particulate Systems, Cauerstr. 3, 91058 Erlangen, Germany — [4]Dept. of Physics, 2401 Stinson Drive, North Carolina State University, Raleigh, NC 27695, USA — [5]Max Planck Institute for Dynamics and Self-Organization, 37077 Göttingen, Germany — [6]Université de Paris, Institut de physique du globe de Paris, CNRS, F-75005, Paris, France

When dense granular matter is sheared, the strain is often localized in shear bands. After some initial transient these shear bands become stationary. Here we introduce a setup that periodically creates horizontally aligned shear bands which then migrate upwards through the sample. Using X-Ray radiography we demonstrate that this effect is caused by dilatancy, the reduction in volume fraction occurring in sheared dense granular media. Further on, we argue that these migrating shear bands are responsible for the previously reported periodic inflating and collapsing of the material.

Ref.: Kollmer *et al.* Phys. Rev. Lett. 125, 048001 (2020)

DY 13.6 Mon 16:40 DYc

Force chains in granular packings visualized by stress-birefringent spheres — •David Fischer[1], Karsten Tell[2], Peidong Yu[2], Matthias Sperl[2], and Ralf Stannarius[1] — [1]Otto-von-Guericke-Universität, Institut für Physik, Abteilung Nichtlineare Phänomene, Magdeburg — [2]Deutsches Zentrum für Luft- und Raumfahrt (DLR), Institut für Materialphysik im Weltraum, Köln

Force networks play an important role in the stability of granular packings. These networks are able to redirect part of the particle weight inside a container to the side walls, leading to pressure saturation in a certain depth below the granular surface. We employ monodisperse stress-birefringent spheres embedded in an immersion fluid to visualize the contact forces and force network structure of spheres in a quasi-2D and a nearly-2D cuboid cell. A load at the top prevents floating of the spheres caused by buoyancy. In both cell types, an "inverse" Janssen effect is observed, with the pressure decreasing from the top to the bottom of the container.

DY 13.7 Mon 17:00 DYc

Intermittent flow and transient congestions of soft low-

friction spheres in silo discharge — •Jing Wang[1], Kirsten Harth[1], Ralf Stannarius[1], and Tamas Börzsönyi[2] — [1]Institute of Physics, Otto von Guericke University, Magdeburg, Germany — [2]Institute for Solid State Physics and Optics, Wigner Research Center for Physics, Budapest, Hungary

During discharge of hard particles from a silo with a small orifice at the bottom, grains flow freely only when the orifice size at least 5 times the particle diameter. The outflow rate is practically independent of the fill level. Below a certain outlet diameter, hard particles reach stable clogs, which can only be destroyed by external forcing. We study soft, low-friction particles (hydrogel beads) that show very different, peculiar features during discharge: They flow freely even when the orifice is only slightly larger than two particle diameters. At small orifice sizes, strong fluctuations of the flow velocity set in. Non-permanent congestions are characteristic that have previously been described only for lifestock or pedestrians passing narrow gates or exits, but never for inanimate hard granular material. We present experimental data recorded in a 2D silo.

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