DY 21: Granular Matter / Contact Dynamics

Time: Wednesday 15:00–18:15 Location: H47

DY 21.1 Wed 15:00 H47

Granular Gases of Rodlike Grains in Microgravity Experiments — •Kirsten Harth, Kathrin May, Torsten Trittel, Sandra Wegner, and Ralf Stannarius — Institut für Experimentelle Physik, Otto-von-Guericke-Universität Magdeburg, Germany

Understanding the dynamics of granular materials is relevant both in fundamental physics and from the technological point of view, but many well-known phenomena are still insufficiently understood. Granular gases are dilute ensembles of macroscopic grains, interacting by inelastic collisions. Permanent energy supply is required to maintain dynamic equilibrium. Granular gases of spherical grains have been widely investigated theoretically and in experiments in 2 dimensions. Microgravity is necessary for maintaining such a gas in 3 dimensions (3D). Only dynamics in the Knudsen-regime and clustering instabilities were accessible in previous experiments. Our experiment with rodlike grains offers access to statistical dynamics in the rod-rod collision dominated regime as well as the oppotunity to measure the rotational degrees of freedom of the particles. We present recent results from sounding rocket and drop-tower experiments. Ensembles of rods are confined in a 3D container, monitored by video cameras. Individual rods are tracked in consecutive frames. We analyse spatial and temporal density fluctuations, translational and rotational velocity distributions, the partition of kinetic energy and the influence of different experimental parameters.

DY 21.2 Wed 15:15 H47

Shear Alignment Of Shape-Anisotropic Granular Material — •Sandra Wegner[1], Tamás Börzsönyi[2], Ralf Stannarius[1], and Balázs Szabó[2] — [1]Otto-von-Guericke Universität Magdeburg, Institute for Experimental Physics, D-39016 Magdeburg, Germany — [2]Institute for Solid State Physics and Optics, Wigner Research Center for Physics, Hungarian Academy of Sciences, P.O. Box 49, H-1525 Budapest, Hungary

Flow of large ensembles of elongated and flat granular particles - often encountered in nature or industry - can induce pronounced alignment of the building blocks. This phenomenon is well known, e. g. in geophysics, but hardly understood quantitatively.

We explore the shear induced orientational order and alignment inside the macroscopic material using X-ray computed tomography (CT). The preferred orientation of the long axes of the particles encloses a small angle with the streamlines in the sheared region.

Our observations demonstrate that the effect of shear alignment of dry elongated particles is very similar to the well-studied case of liquid crystals, irrespectively of the completely different types of interparticle forces. Nematic continuum theory can be used to predict some features of grain alignment.

Extracting the orientations of large numbers of particles by CT image analysis enables us to calculate a local order tensor for the system. From the tensor properties we derive the average orientation, the primary and the biaxial order parameters for the stationary state and two types of transients. In addition single particle dynamics are studied.

DY 21.3 Wed 15:30 H47

A local view on sheared granular matter — Jean-François Métayer[1], Annika Döring[1], Song-Chuan Zhao[1], Mario Scheel[2], and •Matthias Schröter[1] — [1]Max Planck Institute for Dynamics and Self-Organization, Göttingen — [2]ESRF, Grenoble, France

Whenever granular material flows along a stationary boundary, it is sheared. Examples reach from downhill avalanches to industrial hopper flows. Inside the shear flow, the volume fraction will change depending on the initial density; loose packings will compact when sheared, dense samples will expand. The transition between these two responses is called dilatancy onset. At present our understanding of it is still mostly phenomenological, e.g. there is no theory predicting the volume fraction of dilatancy onset as a function of friction, shape, or pressure.

This talk will present a local view of sheared sphere packings using fast X-ray tomography at the European Synchrotron Radiation Facility ESRF in Grenoble. While we find no scaling of the volume response with the contact number, as stipulated by the Jamming paradigm, we do see a dependence on the local volume fraction and the local strain rate.

DY 21.4 Wed 15:45 H47

Self-organized changes in the transient behavior of sheared granular materials — •János Török[1], Tamás Börzsönyi[2], and Balázs Szabó[2] — [1]institute of Physics, Budapest University of Technology and Economics, H-1111 Budapest, Hungary — [2]Institute for Solid State Physics and Optics, Wigner Research Center for Physics, Hungarian Academy of Sciences, P.O. Box 49, H-1525 Budapest, Hungary

Recently the kinetic elastoplastic model was introduced to describe the shearing of granular material. It is based on the separation of elastic and plastic deformation where the plastic events modify the local shear stress. Here we propose a mesoscopic model which captures the essence of the kinetic elastoplastic model while making it usable for more complicated geometries like modified Couette cell. We show that in the transient phase the flow gets narrower and this is due to the change in the distribution of the material density around the shear zone. The results are tested against CT and surface video measurements which show perfect agreement in both width and density evolution.

DY 21.5 Wed 16:00 H47

Collective Granular Dynamics in a Shaken Container at Low Gravity Conditions — •Jonathan Kollmer, Achim Sack, Michael Heckel, Fabian Zimber, and Thorsten Pöschel — MSS, FAU Erlangen-Nürnberg, Erlangen, Germany

A rectangular container partially filled with steel beads is subjected to sinusoidal motion at a set of frequencies, and amplitudes that are comparable to the length of the container. We observe the dynamics inside during the low gravitational acceleration achieved on a parabolic flight. An optical flow method is used to study the compaction dynamics and particle wall collisions are characterized using a microphone. We see different regimes of excitation from a very loose state to a more ordered "collect & collide" behavior. We compare the experimental data to force-based molecular dynamics simulations and investigate the limits of describing the system using an effective one-particle model. Understanding the dynamics of this kind of system allows for better modeling and optimization of, for example, granular dampers.

DY 21.6 Wed 16:15 H47

Measurement of rotation of individual spherical particles in cohesive granulates — •Jennifer Wenzl[1], Ryohei Seto[1,2], Marcel Roth[1], Hans-Jürgen Butt[1], and Günter K. Auernhammer[1] — [1]Max Planck Institute for Polymer Research, Mainz, Germany — [2]Benjamin Levich Institute for Physico-Chemical Hydrodynamics, New York, NY 10031, USA

To explore dynamical processes in granular matter, we use a combination of 3D imaging and mechanical testing. We analyze structural changes using confocal microscopy while applying a compression load simultaneously. Fluorescently labeled polydisperse silica particles were hydrophobized with long alkyl chains and dispersed in an index-matching liquid. The particles show a weak attraction. Photobleaching the central plane of individual particles generates an optical anisotropy without changing particle interaction. In a series of 3D images, we follow trajectories and rotation of single particles [1]. We focus on particle translation and rotation in dependency of the local volume fraction. During compression, restructuring happens predominantly in regions of low packing density. We show that rotation plays an important role and is hence a key parameter for explaining dynamical processes in granular systems.

[1] Wenzl, et al, Granul. Matter (2012), doi:10.1007/s10035-012-0383-7

15 min. break

DY 21.7 Wed 16:45 H47

Measuring the Mechanical Properties of a Granular Suspension — •Chih-Wei Peng and Matthias Schröter — Max-Planck-Institute for Dynamics and Self-Organization

The mechanical properties of granular suspensions differ from normal liquids. Fluidized beds are often used to study such systems. By changing the flow rate, one can achieve different states, from suspension at

high flow rate to solid-like sediment at low flow rate.

Our experiment system is a torsion pendulum which is partially immersed into a fluidized bed. We apply a sinusoidal magnetic field to drive the torsion pendulum. The complex susceptibility $\tilde{\chi}(\omega)$ can be obtained by the ratio of driving torque and the response deflection angle, the latter being measured by a reflected laser beam and a quadrant photodiode. This ratio can be used to determine the viscosity of this system by using the Langevin equation.

Moreover, this method can also be applied to measure an effective granular temperature based on a fluctuation dissipation theorem.

DY 21.8 Wed 17:00 H47

Surface melting of wet granular matter in two dimensions — Christopher May, Ingo Rehberg, and •Kai Huang — Experimentalphysik V, Universität Bayreuth, 95440 Bayreuth, Germany

Surface melting has been a topic of interest since Michael Faraday's observations on regelation, welding of two blocks of ice after contact below 0 degree. From the qualitative idea of surface energy reduction to quantitative experimental tests, it becomes clear nowadays that melting is a continuous process that tends to start from the free surface.

In the present investigation, we address the 'melting' scenario of a monolayer of wet glass beads under horizontally swirling motion experimentally. Due to the cohesion arising from the formation of capillary bridges between adjacent particles, the particles initially form a crystalline structure at moderate driving. As the strength of driving increases, this structure is found to melt with two steps: A reshaping into a circular shape while keeping a locally hexagonal structure, followed by a melting from the surface. Quantitative characterizations on local packing density and bond orientational order parameters both reveal a critical swirling frequency for the start of surface melting, which can be rationalized with a balance between the energy injection and the barrier for the structure change of surface particles.

DY 21.9 Wed 17:15 H47

Equilibration of liquid morphologies in granulates with different wettability — •Marc Schaber[1], Mario Scheel[3], Martin Brinkmann[1,2], Marco Di Michiel[3], and Ralf Seemann[1,2] — [1]Experimental Physics, Saarland University, D-66041 Saarbrücken — [2]MPI for Dynamics and Self-Organization, D-37073 Göttingen — [3]European Synchrotron Radiation Facility, 6 rue Jules Horowitz, F-38000 Grenoble

When adding liquid to dry granulates, the liquid forms individual capillary bridges or a network of liquid morophologies depending on the amount of liquid and the wettability of the granules. Fairly monodisperse glass and basalt microspheres of different diameters are used as granules having small and large contact angle, respectively. By fluidizing the granulate, the packing geometry of the granules is temporarily changed and accordingly the liquid distribution is destroyed. Using ultra-fast X-ray tomography we explore the time resolved re-distribution of liquid after stopping the fluidization and the re-formation of a new equilibrium distribution of the liquid. For non-wettable basalt beads no liquid redistribution was found. For wettable glass beads, however, a characteristic liquid equilibrium distribution is achieved after a time scale which depends on bead diameter, the viscosity and the amount of the added liquid.

DY 21.10 Wed 17:30 H47

Scaling of the normal coefficient of restitution for wet impacts — •Thomas Müller[1], Frank Gollwitzer[1], Christof A. Krülle[2], Ingo Rehberg[1], and Kai Huang[1] — [1]Experimentalphysik V, Universität Bayreuth, 95440 Bayreuth, Germany — [2]Maschinenbau und Mechatronik, Hochschule Karlsruhe - Technik und Wirtschaft, 76133 Karlsruhe, Germany

For the understanding of the dynamics of granular matter, it is important to know about the dissipation of energy due to inelastic collisions at the particle level. For dry granular matter, there are successful examples describing its dynamical behaviour based on appropriate collision models. In contrast, a continuum description for wet granulate, which considers the cohesion arising from the wetting liquid phase, is not yet established.

We investigate the coefficient of restitution (COR) by tracing a freely falling sphere that rebounds from a flat wetted surface. Our goal is to understand the energy dissipation process of a wet impact and to find a collision law which is appropriate for modelling the dynamics of granular matter. The dependence of the COR on the impact velocity as well as the properties of the particles and the liquid film is presented and discussed in terms of dimensionless numbers which characterize the interplay between inertial, viscous and surface forces. In particular, we discuss the scaling of the COR on various density and size ratios between the particle and the liquid film for liquids with different viscosities.

DY 21.11 Wed 17:45 H47

Compaction of Frictional Octahedra — •N Nirmal Thyagu, Max Neudecker, Stephan Herminghaus, and Matthias Schroeter — Max Planck Institute for Dynamics and Self-Organization, Goettingen, Germany

We perform experiments with frictional polypropylene octahedra to study the packing properties. Starting with the loose packing, compaction of octahedra is done by two types of forcing - a) tapping and b) shearing. The compaction gives rise to crystallization of octahedra due to heterogenous nucleation from the walls. We obtain the X-ray tomograms of the packing configurations as a function of packing fraction. From the contact geometries we obtain results for the packings such as - pair correlation function, distance to isostaticity, and spatial & angular correlation functions. We contrast these results with a similar study on the simplest platonic solid, the tetrahedron [Ref.1] and the sphere.

Reference: 1. Jammed frictional tetrahedra are hyperstatic, M. Neudecker, S. Ulrich, S. Herminghaus, M. Schroeter. (arXiv:1202.6272v2)

DY 21.12 Wed 18:00 H47

Compaction of Cohesive Granular Matter — •Sebastian Seemann, Alexander Weuster, Lothar Brendel, and Dietrich E. Wolf — Faculty of Physics, University of Duisburg-Essen, 47048 Duisburg, Germany

For granular media with grain sizes in and below the μm-range, interparticular cohesion forces have a major influence on the macroscopic behavior of the medium. Especially, the porosity of a granular packing increases with increasing cohesion force. We use molecular dynamics to study the response of cohesive granular matter to uniaxial compression. With increasing pressure, remaining pores within the packing are closed and the porosity therefore decreases. Previous results [1,2] have shown that this dependency (the *compaction law*) is described by a power law. However, a discrepancy regarding the exponent still exists. Our approach to clear up this discrepancy is twofold. On one hand, we study the response of a ballistic aggregate to a fast, pressure-driven compaction and elucidate the effects of particle elasticity. In this case the behavior is more complex. The role of elastic contributions in the case of shock-compaction is discussed. On the other hand, we use a velocity-driven wall to compress the packing in a quasistatic manner. We will show that elastic effects cease to play a role and we present results for the compaction law and its exponent.

[1] D. Kadau. *Porosität in kohäsiven Pulvern und Nano-Pulvern*, Dissertation, Universität Duisburg-Essen (2004)
[2] F. A. Gilabert, J.-N. Roux, and A. Castellanos, Phys. Rev. E **78**, 031305 (2008)