DY 3: Granular Matter

Time: Monday 9:30–12:45 Location: H46

Invited Talk DY 3.1 Mon 9:30 H46

History and Structure of Granular Sediments — •Thorsten Pöschel — Institute for Multiscale Simulation, Friedrich-Alexander Universität, Erlangen-Nürnberg, Germany

We consider the sedimentation of monodisperse granular particles under the influence of gravity. The history of the process is described by the surface of the sediment as a function of time. We show that the resulting structure of the sediment, characterized by the field of contact number is intimately related to the process of sedimentation such that the history of the process, can be completely deduced from the time-independent field of contact number of the sediment.

DY 3.2 Mon 10:00 H46

Mechanical properties of cohesive granular materials — •Arnaud Hemmerle, Matthias Schröter, and Lucas Goehring — Max Planck Institute for Dynamics and Self-Organization (MPIDS), 37077 Göttingen, Germany

Understanding the mechanical properties of cohesive granular materials is important for various problems such as fracturing of rocks, fluid invasion, or seismology. By mixing glass beads with a curable elastic polymer, we create well-defined cohesive granular media, held together by solid capillary bridges. The mechanical response and the toughness of this model material can be tuned over a broad range by adjusting the strength and stiffness of the bridges, as well as the size and cohesion of its constituents. We thoroughly characterized the mechanical properties of this model cohesive granulate for various bead sizes, volume fractions of polymer, and polymer stiffnesses to show the range of behaviors allowed, and their scaling. Using in situ stress-strain tests combined with X-ray micro-tomography, we investigated the links between these macroscopic properties and the microscopic modes of deformation, for example the elongation and the bending of connected neighboring beads.

Along with these fundamental studies of the mechanical response of this model system, we will briefly discuss potential applications of its customizable properties to geoengineering and biophysics, with, for example, investigations on biofouling and bio-deterioration.

DY 3.3 Mon 10:15 H46

Self-organization of wet granular hexagons under vertical agitations — •Manuel Baur and Kai Huang — Experimentalphysik V, Universität Bayreuth, 95440 Bayreuth, Germany

As each sand grain in nature has a peculiar shape, it is of practical importance to understand how shape matters in the collective beahvior of granular materials. As a starting point, we focus on the assembly of hexagonally shaped disks confined in a monolayer and agitated vertically against gravity. The particles are partially wet so as to introduce short ranged attractive interactions at each contact. We explore how the agitation strength and frequency, area fraction as well as cohesion influence the melting of wet granular hexagons by means of particle tracking. Using bond orientational order parameters, we identify the local structures of the particle, determine the nonequilibrium stationary states of the system and present them in a stability diagram. Moreover, we analyze the translational as well as orientational diffusivity of the particles in the vicinity of the melting transition.

DY 3.4 Mon 10:30 H46

$1/f$ noise on the brink of wet granular melting — •Kai Huang — Experimentalphysik V, Universität Bayreuth, 95440 Bayreuth, Germany

The collective behavior of a two-dimensional wet granular cluster under horizontal swirling motions is investigated experimentally. Depending on the balance between the energy injection and dissipation, the cluster evolves into various nonequilibrium stationary states with strong internal structure fluctuations with time. Quantitative characterizations of the fluctuations with the bond orientational order parameter q_6 reveal power spectra of the form f^α with the exponent α closely related to the stationary states of the system. In particular, $1/f$ type of noise with $\alpha \approx -1$ emerges as melting starts from the free surface of the cluster, suggesting the possibility of using $1/f$ noise as an indicator for phase transitions in systems driven far from thermodynamic equilibrium.

DY 3.5 Mon 10:45 H46

Dynamical mesoscopic model for granular shear — •Sára Lévay and János Török — Department of Theoretical Physics, Budapest University of Technology and Economics, H-1111 Budapest, Hungary

Flow law of dense granular material is of fundamental importance and is still an unsolved problem. Different methods are competing in the literature with similar properties yet they fail to predict correctly all empirical results [1]. We introduce a improved version of a simple mesoscopic model [2] based on the principle of minimal dissipation and random local dynamic effects to reproduce both quasi-static and dynamic flow laws. We test our model against other theories and numerical simulations and show that in spite of its simplicity it can provide more precise results than other methods.

[1] Alexander Ries, Lothar Brendel, and Dietrich E. Wolf. "Shearrate diffusion and constitutive relations during transients in simple shear." Computational Particle Mechanics (2015): 1-8.

[2] Tamás Börzsönyi, Balázs Szabó, Gábor Törös, Sandra Wegner, János Török, Ellák Somfai, Tomasz Bien, and Ralf Stannarius "Orientational Order and Alignment of Elongated Particles Induced by Shear" Phys. Rev. Lett. 108, 228302 (2012).

15 min. break.

DY 3.6 Mon 11:15 H46

Declustering in a granular gas as a finite size effect — •Mathias Hummel and Marco Giacomo Mazza — Max Planck Institute for Dynamics and Self-Organization

For realistic models of granular collisions, where the coefficient of restitution depends on the impact velocity, the existence of dense clusters has been shown to be a transient phenomenon. We report direct numerical simulations that elucidate the conditions for the disappearance of structures. We find that upon cluster formation the granular temperature and the convective kinetic energy couple and both follow Haff's law. Furthermore, we show that clusters will eventually dissolve in all finite size systems. We find the strong power law $t' \propto L^{12}$ for the declustering time. Our results imply that only in systems close to the initial critical system size both the clustering and declustering transitions are observable.

DY 3.7 Mon 11:30 H46

Structure and Mechanics of Ellipsoid Packings — •Simon Weis[1], Fabian Schaller[1], Gerd Schröder-Turk[2], and Matthias Schröter[3] — [1]Theoretische Physik 1, FAU Erlangen, Germany — [2]School of Engineering and IT, Murdoch University, Australia — [3]Institute for Multiscale Simulation, FAU Erlangen, Germany

Friction and adhesive forces are important parameters for the stability of granular packings. We examine the structural and mechanical properties of packings in respect to those parameters. Although friction has an impact on the mechanical characteristics, the analyzed local structural features remain unchanged.

The particles of interest are ellipsoids with two types of aspect ratios as well as spheres as a reference system. Interparticle friction is changed by grinding the particles with different abrasives as well as by applying liquid and dry lubricants, which also changes adhesive forces. The friction coefficient is measured using an inclined plane. Various packings with a range of friction coefficients are prepared using different preparation methods to obtain a range of packing fractions.

To obtain structural properties, the packings are recorded by X-ray tomography and the particles are detected. Structural characterization includes mean and local packing fractions, contact numbers as well as voronoi cell anisotropy by Minkowski tensors. The mechanical features are examined within a shear cell setup.

DY 3.8 Mon 11:45 H46

Hopper flow of shape-anisotropic grains — •Ahmed Ashour and Ralf Stannarius — Otto-von-Guericke-Universität Magdeburg, Institut für Experimentelle Physik

Granular materials have unusual and sometimes counterintuitive physical properties. For this reason, despite the fact that they have been involved in pharmaceutical, industrial, and agricultural applications since decades, centuries, and even millennia, they were and still are the subject of intense scientific research. One of the important problems in processing such materials is silo outlet, which has been studied with spherical grains in numerous publications before. We study experimentally the clogging of elongated granular materials during discharge from a flat bottom silo when the orifice size is not much bigger than the grain size. We check if there exists a critical radius of the orifice at which there is no clogging but continuous flow. The change in the flow velocity of the particles from the silo with changing radius of the orifice is studied, and we check the validity of Beverloo's equation for different geometric parameters

DY 3.9 Mon 12:00 H46

Hopper flow of nonspherical granular particles — •János Török[1], Gábor Szabó[2], Ellák Somfai[2], and Tamás Börzsönyi[2] — [1]Department of Theoretical Physics, Budapest University of Technology and Economics, H-1111 Budapest, Hungary — [2]Institute for Solid State Physics and Optics, Wigner Research Center for Physics,

We present experimental results of hopper flow with spherical and nonspherical granular particles. We show that the flow widens with the increasing hopper flow angle, but shrinks with the increasing particle aspect ratio, where the flow also gets more intermittent with a well defined frequency. The results are compared to a mesoscopic model based on the principle of minimal dissipation. We show that due the the elongated particles the shape of the flow changes and becomes more straight.

DY 3.10 Mon 12:15 H46

Spontaneous heaping and secondary flows in sheared granular materials — •David Fischer[1], Ralf Stannarius[1], and Tamás Börzsönyi[2] — [1]Otto von Guericke University, Magdeburg, Germany — [2]Wigner Research Center for Physics, Hungarian Academy of Sciences, Budapest, Hungary

Cylindrical containers with a rotating bottom disk (so-called split-bottom geometry) are well established devices to shear granular materials in a continuous way, and to generate well-defined localized shear bands in the granular bed. When granular material composed of anisotropic grains is sheared in such a container, a secondary flow is generated that leads to the formation of a considerable heap of material near the rotation axis. Superficially, it reminds of the Weissenberg effect in polymer solutions. This process is analyzed for different materials, and its quantitative dependence upon geometric and dynamic parameters is investigated. We find secondary flow and heaping in all investigated anisometric granular materials, both for prolate and oblate shapes. For spherical or nearly-spherical grains, this phenomenon is completely absent.

DY 3.11 Mon 12:30 H46

Why Mikado is one of the easier granular problems — Cyprian Lewandowski[1], Pascal Wieland[2], Max Neudecker[3], Claus Heussinger[2], and •Matthias Schröter[3,4] — [1]Imperial College, London, UK — [2]Georg-August University of Göttingen, Germany — [3]MPI for Dynamics and Self-Organization, Göttingen, Germany — [4]Friedrich Alexander Universität, Erlangen, Germany

The mechanical stability of a granular packing depends on the number of contacts Z between its particles. For most particle shapes, predicting Z as a function of the average volume fraction ϕ is complicated by the spatial correlations between simultaneously contacting particles. However, in the dilute packings formed by cylinders with large aspect ratios α (length of the cylinder divided by its diameter) the individual contacts can be expected to become uncorrelated. Philipse (Langmuir **12**, 1127 (1996)) derived from this idea the Random Contact Model (RCM) which predicts $Z_{RCM} = 2\alpha\phi$. Using X-ray tomography of packings of frictional spaghetti and simulations of frictionless spherocylinders we measure how Z depends on α and ϕ. We find that a non-zero friction coefficient μ increases the range of ϕ where mechanically stable packings exist, but the average Z value seems to be not influenced by μ. For α in the range 15 to 80 the measured Z is smaller or equal to $0.85 Z_{RCM}$. We show that this difference can be explained by the way the RCM defines contacts.