DY 33: Granular Matter and Granular Dynamics I

Time: Wednesday 9:30–12:45 Location: ZEU 118

Invited Talk DY 33.1 Wed 9:30 ZEU 118

Statistical Mechanics of Granular Clogging — •Douglas Durian — University of Pennsylvania, Philadelphia PA, USA

The gravity-driven flow of grains from a hole in a hopper is an iconic granular phenomenon. It's different from a fluid in that the rate is constant also in that it can suddenly and unexpectedly clog. How does the susceptibility to clogging decrease with increasing hole size, and is there a well-defined clogging transition above which the system never clogs? This problem is distinct from jamming due to the presence of boundaries and gradients. We show how the fraction F of flow configurations that cause a clog may be deduced from the average mass discharged between clogs. We construct a simple model to account for the observation that F decays exponentially in hole width to the power of dimensionality. Thus the clogging transition is not sharp but rather is defined by observation limits, similar to the glass transition. When the system is immersed in water, F barely changes. Therefore, grain momenta play only a secondary role in destabilizing weak incipient arches and the crucial microscopic variables are likely the grain positions. Work is now in progress to distinguish free-flowing versus clog-causing position microstates using machine learning.

DY 33.2 Wed 10:00 ZEU 118

Tuning Mechanical Properties of Granular Matter Via Confinement — •Rishab Handa, Jorge Fiscina, and Christian Wagner — Department of Experimental Physics, Saarland University, Saarbruecken, Germany

We compare the high energy dissipation dynamics of dry and wet granular matter subjected to several degrees of confinement under large amplitude oscillatory shear (LAOS). Under confinement, the energy dissipated by dry grains was more pronounced than wet grains, at increasing strain rate. Scaling the elastic modulus of dry grains as a function of shear stress revealed a power law behavior, which we relate to the formation of filament-like force-chain networks. Contrarily, for wet granular matter, linear dependence of elastic modulus indicated the process of breaking and regeneration of capillary bridges, seemingly caused by non-affine motions of grains associated with the noise temperature. Therefore, we show that the degree of confinement can be used as a controlling parameter to adjust the mechanical properties of granular matter.

DY 33.3 Wed 10:15 ZEU 118

Machine Learning aided tracking of rod-like particles in 3D microgravity experiments on granular gases — •Dmitry Puzyrev, Kirsten Harth, Torsten Trittel, and Ralf Stannarius — Institute for Experimental Physics, Otto von Guericke University, Magdeburg, Germany

Granular gases are nonlinear systems which exhibit fascinating dynamical behavior far from equilibrium, including unusual cooling properties, clustering and violation of energy equipartition. Our investigation is focused on 3D microgravity experiments with dilute ensembles of rod-like particles, where the mean free path is substantially reduced as compared to gases of spherical grains of identical volume fraction [1]. Moreover, elongated particles provide the possibility to efficiently study the energy transfer between the translational and rotational degrees of freedom.

One particular problem is the reliable detection and tracking of the rods in 3D, especially at volume fractions beyond the very dilute limit. We have developed a Machine Learning aided approach to the experimental data analysis which allows to recognize and track individual particles in ensemble.

[1] K. Harth et al., Free cooling of a granular gas of rodlike particles in microgravity, Phys. Rev. Lett., 120 (2018), 214301

DY 33.4 Wed 10:30 ZEU 118

Influence of high temperature exposure on adhesive forces in chondritic material — •Cynthia Pillich[1,2], Tabea Bogdan[1], Joachim Landers[1,2], Gerhard Wurm[1], and Heiko Wende[1,2] — [1]Faculty of Physics, University of Duisburg-Essen, 47057 Duisburg, Germany — [2]Faculty of Physics and Center for Nanointegration Duisburg-Essen (CENIDE), University of Duisburg-Essen, 47057 Duisburg, Germany

The growth of planetesimals at the so called „bouncing barrier" is still not fully understood. Compositional and concomitant structural changes of protoplanetary dust induced by high temperatures in the vicinity of the young star might explain improved sticking at the mm-range. As meteorites contain primordial phases representing the material in our young solar system, they offer an insight into the mechanics of planetary formation. A fragment of the iron rich meteorite „Sayh al Uhaymir" was ground and subsequently heated in vacuum at temperatures up to 1400 K and adhesive forces were determined by Brazilian tests after cooling down to room temperature. We present an altered behaviour of adhesive forces in meteoritic matter upon exposure to high temperatures accompanied by a compositional and structural change, which was investigated by ^{57}Fe Mössbauer spectroscopy probing the abundance of iron bearing phases.

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DY 33.5 Wed 10:45 ZEU 118

Pauling Structures in Tribocharged Granular Media — •Philip Born, Jan Haeberle, and Matthias Sperl — Institut für Materialphysik im Weltraum, DLR e.V., Linder Höhe, 51147 Köln

Ordered, non-densest packings of granular particles are rarely observed. The hard core and the frictional contacts of the particles impose disordered packings, or, under suitable conditions like mobilization and small size dispersity of the particles, ordered densest packings with hexagonal symmetry. However, we could show that binary packings of granular particles with strong tribocharging take BCC-like packing structures under suitable conditions [1]. The observed packing behavior is to large extent in agreement with the prediction of Pauling's rules for ionic crystals, i.e., equilibrium structures of thermal ions. Here we want to discuss the observation that the Pauling structure is only observed in an incommensurate container, which may give a hint on the rules how granular media take equilibrium structures with suitable mobilization.

[1] J. Haeberle, J. Harju, M. Sperl and P. Born, "Granular ionic crystals in a small nutshell", Soft Matter 15, 7179-7186 (2019).

DY 33.6 Wed 11:00 ZEU 118

Particle shape-dependence of the stability properties of granular piles — •Steffen Richters-Finger and Stefan J. Linz — Institut für Theoretische Physik, Westfälische Wilhelms-Universität Münster, Germany

It is well known that the shape of particles has a major influence on the behavior of densely packed granular matter making it an important subject of interest for various applications. Multiple schemes for the numerical simulation of non-spherical particles have previously been proposed in the literature [1].

Applying a discrete function representation (DFR) approach for collision detection, we investigate the shape-dependence of the stability properties (e.g. critical angle of stability) of a granular pile in a two-dimensional discrete element model for a wide range of polar geometries generated by the so-called superformula [2].

[1] G. Lu, J.R. Third, C.R. Müller, Chem. Eng. Sci. 127, 425 (2015).
[2] J. Gielis, Am. J. Bot. 90, 333 (2003).

DY 33.7 Wed 11:15 ZEU 118

Using machine learning to identify variables of a granular theory — •Ansgar Kühn and Matthias Schröter — Max-Planck Institute for Dynamics and Self-organization (MPIDS), Göttingen, Germany

The prediction of contact numbers in granular packings using the local package fraction is described by a theory from [1]. In order to find higher order corrections to that theory, a more detailed descriptions of the local geometry is given by the Minkowski tensors of the Voronoi cell. With this data, machine learning provides a more accurate prediction of contact numbers than [1]. Thus, it can be used to identify new variables relevant for the prediction in order to expand the theory.

[1] Song, C., Wang, P., & Makse, H. A. (2008). Nature, 453, 629.

15 min. break.

DY 33.8 Wed 11:45 ZEU 118

Triboelectric charges in granular materials, from their mea-

surement to their effects — •Geoffroy Lumay and Nicolas Vandewalle — GRASP Laboratory, CESAM Research Unit, University of Liège, Belgium

It is well known in industrial applications involving powders and granular materials that the presence of electrostatic charges influences drastically the material properties. The apparition of electrostatic charges is due to the triboelectric effect at the contacts between the grains and also at the contacts between the grains and the container. This triboelectric effect in granular materials is drastically influenced by humidity and is still poorly understood from a fundamental point of view. Moreover, reproducible electrostatic measurements are difficult to perform. A few years ago, we developed an experimental device dedicated to the measurement of powder triboelectric properties. This device is now commercialized under the name GranuCharge by the company GranuTools and measures the ability of a powder to charge electrostatically during a flow in contact with a selected material. In this presentation, we will analyse the link between powder electrostatic properties, hygrometry and powder macroscopic properties (packing fraction, cohesiveness, flow, ...) from a fundamental point of view. Afterward, we will show how flow aid agents can be used to decrease the cohesiveness of industrial powders by playing a role on both capillary and electrostatic forces.

This study was conducted in the framework of the PowderReg project, funded by the European programme Interreg VA GR

DY 33.9 Wed 12:00 ZEU 118

Collective abrasion of pebbles — •János Török[1,2], András Sipos[1,3], and Gábor Domokos[1,2] — [1]MTA-BME Morphodynamics Research Group, Budapest University of Technology and Economics — [2]Department of Theoretical Physics, Budapest University of Technology and Economics — [3]Department of Mechanics, Materials and Structures, Budapest University of Technology and Economics

Fragments of rocks start their life after removal from their original position. Natural elements take over the formation of the resulting pebbles. Much is known about the evolution of the shapes of the pebbles depending on the size of the object they collide with. However the abrasion of these fragments never happens in a solitary manner rather it is a collective phenomenon.

We investigate the collective equations driving the particle size probability distribution functions and identify the stationary distributions. We examine the possible physical processes and derive the corresponding partial differential equations for the collective process. These physical models have to take into account the actual particle size distribution the collision probability, the relative velocities of the particles and the collision energy.

We analyze the resulting models using both stochastic simulation and direct simulations of the Fokker-Planck equations. We analytically identify the cases where unimodal or bimodal particle size distribution can be obtained in the stationary state.

DY 33.10 Wed 12:15 ZEU 118

Superballistic propagation of density correlations in quenched granular media — •Thomas Schindler[1], Christian M. Rohwer[2], and Sebastian C. Kapfer[1] — [1]Institut für Theoretische Physik I, Universität Erlangen-Nürnberg, Staudtstraße 7, 91058 Erlangen, Germany — [2]Max Planck Institute for Intelligent Systems, Heisenbergstr. 3, 70569 Stuttgart, Germany

We investigate granular particles in a shaken quasi two dimensional box in molecular dynamics computer simulations. After suddenly changing the shaking amplitude, transient density correlations are observed, that go beyond the steady state correlation length scale. Propagation of the correlations is faster than ballistic for increasing as well as decreasing amplitude, which is in contrast to recently investigated quenches of Brownian particles that show diffusive propagation. [1,2] When performing simulations with side walls, we find finite size effects for the wall pressure in steady state simulations and an additional transient pressure contribution when changing the shaking amplitude. We treat the question if the observed effects with and without side walls originate from the same mechanisms.

[1] Christian M Rohwer, Mehran Kardar, and Matthias Krüger. Transient Casimir Forces from Quenches in Thermal and Active Matter. Physical Review Letters, **118** (2017), 015702

[2] Christian M Rohwer, Alexandre Solon, Mehran Kardar, and Matthias Krüger. Nonequilibrium forces following quenches in active and thermal matter. Physical Review E, **97** (2018),032125

DY 33.11 Wed 12:30 ZEU 118

Flow study for transparent model system of concrete and cement paste — •Himanshu P Patel[1] and Günter K Auernhammer[1,2] — [1]Leibniz-Institut für Polymerforschung Dresden e. V., Hohe Straße 6, D-01069 Dresden, Germany — [2]Max Planck Institute for Polymer Research, Ackermannweg 10 - D-55128 Mainz, Germany

The study of internal dynamics in a complex granular suspension, such as flowing concrete, poses couple of scientific challenges. Concrete, being opaque, restricts the possibility of optical observations. Non-optical techniques such as Ultrasonic and slipper test provides limited understanding.

We here demonstrate the development of highly transparent model system for concrete. The system is an optically transparent dense granular suspension (42% to 48% by volume) that mimics rheology behavior of concrete on the parameters of shear stress and viscosity. Further, we analyze the flow in continuous phase using specific experimental setup. The setup allows vertical and horizontal flow analysis, to understand shear and plug flow in addition to insight about lubrication layer formation. The study is part of understating flow induced particle migration for dense granular suspensions.

The flow profile of model concrete is observed using high-speed camera and tracer particles are used to undertake the study.