# DY 11: Granular Matter and Contact Dynamics

Time: Monday 15:30–18:00 Location: H19

DY 11.1 Mon 15:30 H19

**Measuring the coarsening dynamics of ferromagnetic granular networks under impact of a vertical magnetic field** — Matthias Biersack[1], Oksana Bilous[2], Pedro Sanchez[2], Sofia Kantorovich[2], and •Reinhard Richter[1] — [1]University of Bayreuth, Experimental Physics V, 95447 Bayreuth, Germany — [2]Computational Physics, University of Vienna, 1090 Vienna, Austria

We are exploring in experiments the aggregation process in a shaken granular mixture of glass and magnetized steel beads, occuring in a horizontal vessel after the shaking amplitude is suddenly decreased. Then the magnetized beads form a transient network that coarsens in time into compact clusters, following a viscoelastic phase separation [1]. A homogeneous magnetic field oriented parallel to the system plane has been observed to "unknot" network structures orthogonal to the field [2]. Here we focus on the impact of a homogeneous magnetic field oriented in vertical direction. For certain field amplitudes we observe a three-phase state, namely mobile glass beads, a grid of isolated steel beads and the coarsening network. Our results demonstrate that via dipole-dipole repulsion the field reduces the mobility of isolated steel beads, thus hindering the growth of the networks. The experimental results are compared with those of numerical simulations.

[1] A. Kögel, et al. *Soft Matter*, 14 (2018) 1001.

[2] P. A. Sánchez, J. Miller, S. S. Kantorovich, R. Richter, *J. Magn. Magn. Mater*, 499 (2019) 166182.

DY 11.2 Mon 15:45 H19

**Dynamic light scattering from single macroscopic particles** — •Philip Born and Lisa Dossow — Institut für Materialphysik im Weltraum, Deutsches Zentrum für Luft- und Raumfahrt (DLR), 51170 Köln, Germany

Here we present a methodology to extract information from the light intensity fluctuations that arise from motion of single granular particles. We first describe the experimental setup for dynamic light scattering measurements and the associated theoretical framework required to isolate contributions from the translational motion and from the rotational motion to the intensity autocorrelation function [1]. We subsequently present an approach to extract the angular velocity and the translational speed of the granular particles from the intensity autocorrelation. The approach is applied to a small ensemble of granular particles in an hour-glass-like experiment to determine the granular temperature with a dynamic light scattering measurement. The results indicate the next steps to be taken to eventually develop a thermometer for fluidized granular media based on dynamic light scattering.

[1] L. Dossow, R. Kessler, M. Sperl & P. Born, Dynamic light scattering from single macroscopic particles. Applied Optics, 60(32), 10160-10167 (2021).

DY 11.3 Mon 16:00 H19

**Structural Analysis of Disordered Dimer Packings** — •Esma Kurban and Adrian Baule — School of Mathematical Sciences, Queen Mary University of London, Mile End Road, London E1 4NS, UK

Jammed disordered packings of non-spherical particles show significant variation in the packing density as a function of particle shape for a given packing protocol. Rotationally symmetric elongated shapes such as ellipsoids, spherocylinders, and dimers, e.g., pack significantly denser than spheres over a narrow range of aspect ratios, exhibiting a characteristic peak at aspect ratios of $\alpha_{\max} \approx 1.4 - 1.5$. However, the structural features that underlie this non-monotonic behaviour in the packing density are unknown. Here, we study disordered packings of frictionless dimers in three dimensions generated by a gravitational pouring protocol in LAMMPS. Focusing on the characteristics of contacts as well as orientational and translational order metrics, we identify a number of structural features that accompany the formation of maximally dense packings as the dimer aspect ratio $\alpha$ is varied from the spherical limit. Our results highlight that dimer packings undergo significant structural changes as $\alpha$ increases up to $\alpha_{\max}$ manifest in the reorganisation of the contact configurations between neighbouring dimers, increasing nematic order, and decreasing local translational order. Remarkably, for $\alpha > \alpha_{\max}$ our metrics remain largely unchanged, indicating that the peak in the packing density is related to the interplay of structural rearrangements for $\alpha < \alpha_{\max}$ and subsequent excluded volume effects with unchanged structure for $\alpha > \alpha_{\max}$.

**15 min. break**

DY 11.4 Mon 16:30 H19

**The role of the particle aspect ratio in the discharge of a narrow silo** — •Bo Fan[2,4], Tivadar Pongó[1,2], Dariel Hernández-Delfin[1,5], János Török[3], Ralf Stannarius[6], Raúl Cruz-Hidalgo[1], and Tamás Börzsönyi[2] — [1]Universidad de Navarra, Pamplona, Spain — [2]Wigner Research Centre for Physics, Budapest, Hungary — [3]Budapest University of Technology and Economics, Budapest, Hungary — [4]Wageningen University, Wageningen, The Netherlands — [5]Basque Center for Applied Mathematics, Bilbao, Spain — [6]Otto von Guericke University, Magdeburg, Germany

The time evolution of silo discharge is investigated for different granular materials made of spherical or elongated grains in laboratory experiments and with discrete element model (DEM) calculations. For spherical grains, we confirm the widely known typical behavior with constant discharge rate (except for initial and final transients). For elongated particles with aspect ratios between $2 < L/d < 6.1$, we find a peculiar flow rate increase for larger orifices, especially in the last third of the discharge process. While the flow field is practically homogeneous for spherical grains, it has strong gradients for elongated particles with a fast-flowing region in the middle of the silo surrounded by a stagnant zone. For large enough orifice sizes, the flow rate increase is connected to a gradual change in the character of the flow field, including a shrinkage of the stagnant zone and an increase in both the packing fraction and flow velocity near the silo outlet.

DY 11.5 Mon 16:45 H19

**Excitation of Platonic bodies on a vibrating plate analyzed with smart IMUs** — •Torsten Trittel, Dmitry Puzyrev, Niklas Dieckmann, and Ralf Stannarius — Otto-von-Guericke Universität Magdeburg

For the investigation of granular gases, i.e. large ensembles of macroscopic particles that interact via frequent mutual collisions, an initial or permanent excitation of the ensembles is prerequisite. Typically, this excitation is realized by one or more vibrating plates (container walls). We investigate such a mechanical excitation of different Platonic bodies, e.g. icosahedra and cubes, and compare their dynamics with that of spherical particles. In earlier experiments with mechanically excited rods [1], the dynamic data were extracted from a huge amount of stereoscopic video data. This procedure is very complicated and time consuming. To overcome this problem, we equipped our particles with small IMUs (inertial measurement units) that are typically used for motion tracking [2]. From acceleration and rotation data, it is straightforward to calculate the rotational and translational energies of each jump. We present distributions of the energies on individual degrees of freedom and determine the efficiency of the excitation depending on vibration parameters. Finally, we compare the experimental findings with results obtained from numerical simulations.

[1] T. Trittel et al., Mechanical excitation of rodlike particles by a vibrating plate, Phys. Rev. E 95, 062904, (2017)

[2] M. Zenker, Dynamik platonischer Körper bei mechanischer Anregung, BA, Magdeburg (2021)

DY 11.6 Mon 17:00 H19

**Rare Fluctuations in Sheared 2D LJ Fluids** — •Daniel Dernbach and Jürgen Vollmer — Institut für Theoretische Physik, Universität Leipzig, Brüderstr. 16, D-04103 Leipzig, Germany

A distinguishing feature of sheared particulate flows are very large fluctuations in the dissipation, i.e. the product of the local velocity gradient and the local shear stress. At times, it even takes negative values (rare fluctuations). Surprisingly, the probability of rare fluctuations vanishes close to jamming [1], a far-from-equilibrium critical point where fluctuations are expected to be large.

Here, we compare this setting to the motion of classical fluids with attractive, elastic interactions. Specifically, we consider the transition from fluid to plastic flow in a two-dimensional (2D) Lennard-Jones (LJ) fluid subjected to a Nosé-Hoover thermostat.

Close to its critical rigidity transition this time-reversible sheared dynamics also features a drop of the probability of rare fluctuations. We will scrutinize the analogies and differences between the emergence of rare fluctuations in irreversible particulate flow and in time-reversible classical dynamics.

[1] Rahbari, Saberi, Park, Vollmer, Nat. Commun. 8, 11 (2017)

DY 11.7 Mon 17:15 H19

**Granular Gases of Mixtures of Rods in Microgravity** — •Kirsten Harth[1,2], Dmitry Puzyrev[3], Torsten Trittel[3], and Ralf Stannarius[3] — [1]Fachbereich Technik, TH Brandenburg, Brandenburg an der Havel, Deutschland — [2]MARS und MRTM, Otto von Guericke Universität Magdeburg, Deutschland — [3]Institut für Physik und MARS, Otto von Guericke Universität Magdeburg, Deutschland

Granular gases consist of macroscopic particles in erratic motion, rarely colliding among each other. They are a comparatively simple, yet illustrative example of a non-equilibrium dynamical system. Numerous theoretical and numerical studies deal with their dynamics, however, the realization of 3D experiments is rare. It usually requires microgravity. Typical experiments are either performed under continuous external energy supply or they consider the process of collective kinetic energy decay by dissipation (granular cooling). It has been recently shown that both ensembles of rods and spheres follow the scaling predicted by Haff in 1983, however, with stark quantitative disagreement with the theory.

Here, we consider a bidisperse ensemble of 2 types of rods in a cuboid container. We track their positions and rotations in 3D. Expererimental data will be compared to validated numerical simulations of frictional rods under similar conditions. We extract kinectic energies in individual degrees of freedom and other statistical quantities.

DY 11.8 Mon 17:30 H19

**Pauling Structures in tribocharged Granular Media** — Jan Haeberle, Matthias Sperl, and •Philip Born — Institut für Materialphysik im Weltraum, Deutsches Zentrum für Luft- und Raumfahrt (DLR), 51170 Köln, Germany

Crystal-like arrangements of granular particles had been studied in the past for their mechanical properties or as a model system to study structure formation of non-equilibrium systems. These studies were limited to the formation of either hcp or fcc densest arrangements of monodisperse spheres. However, in most situations the hard core and the frictional contacts of the granular particles stabilize less dense disordered packings. Here we show that binary packings of granular particles with strong tribocharging spontaneouisly take BCC-like packing structures under suitable conditions [1]. We use a version of the bond-order parameter which is robust against noise to identify crystalline structures x-ray tomography reconstructions [2]. The observed BCC-like packing structures formed in incommensurate containers are, to large extent, in agreement with the prediction of Pauling's rules for ionic crystals, i.e. equilibrium structures of thermal ions.

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

[2] J. Haeberle, M. Sperl and P. Born, "Distinguishing noisy crystalline structures using bond orientational order parameters", EPJ E 42, 1-7 (2019).

DY 11.9 Mon 17:45 H19

**Visualization of flow dynamics for Poly-dispersed dense granular suspension in various sections of pipe** — •Himanshu P Patel and Günter K Auernhammer — Leibniz-Institut für Polymerforschung Dresden e. V., Hohe Straße 6, D-01069 Dresden, Germany

The study of flow dynamics in non-Newtonian media with polydispersed dense granular suspension, e.g., slurry, mud, concrete, still lacks quantification on the flow parameters linked to shear induced particle migration and insight about flow at center and at wall in closed pipes.

We developed transparent granular system that is a granular suspension of particles suspended in non-Newtonian media (particle volume fractions of 30% to 48% ) [1]. The non-Newtonian granular system has yield stress and plastic viscosity and is well index matched. The rheological characteristics of the model system is tunable through its composition of additives.

We analyze gravity-assisted continuous flow of millimetric sized particles. We perform tracking of flow at different sections of pipe. The flow analysis revels understanding on the relaxation of such flow and the development of velocity profile within the length of pipe, we observe this using camera at entry and exit of pipe and later a 3D setup to observe flow at near end of pipe. This gives quantitative values into the particle migration to understand the effect of polydispersity and particle flow.

[1] Auernhammer, Günter K., et al., Materials & Design (2020):108673