DY 21: Granular Matter

Time: Wednesday 9:30–11:30 Location: H43

DY 21.1 Wed 9:30 H43

Coarsening dynamics of ferrogranular networks for different granular temperatures — •Ali Lakkis[1], Matthias Biersack[1], Oksana Bilous[2], Pedro A. Sanchez[2], Sofia S. Kantorovich[2], and Reinhard Richter[1] — [1]University of Bayreuth, Experimental Physics 5, Universitätsstr. 30, 97440 Bayreuth, Germany — [2]University of Vienna, Faculty of Physics, Kolingasse 14-16, 1090 Vienna, Austria

We are exploring in experiments the aggregation process in a shaken granular mixture of glass and magnetized steel beads, filled in a horizontal vessel. After the shaking amplitude is suddenly decreased, the magnetized beads form a transient network that coarsens in time into compact clusters [1]. Recently it has been quantified how a homogeneous magnetic field B oriented in vertical direction impedes the emergence and growth of the networks [2,3], where the mean degree $\bar{k}$ of a node serves as an order parameter. Here we explore the impact of the acceleration amplitude Γ onto the velocity distribution of the particles, their granular temperature, and the coarsening dynamics of the network, i.e. $\bar{k}(\Gamma)$.

[1] A. Kögel, R. Maretzki, E. S. Pyanzina, P. A. Sánchez, S. S. Kantorovich, R. Richter *Soft Matter*, 14 (2018) 1001.

[2] M. Biersack, A. Lakkis, R. Richter, O. Bilous, P. A. Sánchez, S. S. Kantorovich *Phys. Rev. E*, 108 (2023) 054905.

[3] A. Lakkis, M. Biersack, O. Bilous, S. S. Kantorovich, R. Richter, *J. Magn. Magn. Mater* 589 (2024) 171620.

DY 21.2 Wed 9:45 H43

Decoding diffusion: insights into ferrogranulate dynamics under competing interactions — •Oksana Bilous[1], Kirill Okrugin[1], Pedro A. Sánchez[1], Ali Lakkis[2], Matthias Biersack[2], Reinhard Richter[2], and Sofia Kantorovich[1] — [1]Computational and Soft Matter Physics, University of Vienna, Vienna, Austria — [2]Experimental Physics 5, University of Bayreuth, Bayreuth, Germany

Granulates with magnetic and non-magnetic particles exhibit unique diffusion behaviors, challenging conventional models. Using experiments and Langevin dynamics simulations, we studied their dynamics under varying magnetic fields and particle compositions.

In steady states, entropic, dipolar, and field-induced forces create distinct distributions: single particles, cluster-bound particles, and migrating particles transitioning between these states. Sub-diffusion occurs exclusively in magnetic particles within clusters, independent of external fields or concentrations. Glass particles remain non-aggregated.

Velocity distributions in high-shaking experiments validate the use of Langevin dynamics, revealing an effective temperature that links structural separations to thermodynamic scaling laws. These findings deepen our understanding of diffusion and force interactions in complex granular systems.

DY 21.3 Wed 10:00 H43

Advances and challenges in experiments with granular gases of rod-like particles — •Dmitry Puzyrev[1], Torsten Trittel[2,1], Kirsten Harth[2,1], Mahdieh Mohammadi[2], Raul Cruz Hidalgo[3], and Ralf Stannarius[2,1] — [1]Otto von Guericke University, Magdeburg, Germany — [2]Brandenburg University of Applied Sciences, Brandenburg an der Havel, Germany — [3]Univerisity of Navarra, Pamplona, Spain

Granular gases, i.e., ensembles of free-moving macroscopic particles which collide inelastically, demonstrate fascinating dynamical effects like unusual cooling properties, violation of energy equipartition, clustering, and spontaneous collective movement. Our investigation is focused on 3D microgravity experiments with ensembles of rod-like particles [1] and their mixtures. With the help of machine learning methods, we have obtained various statistical properties for the mixture of thinner and thicker rods [2]. Kinetic energy partitions and collision numbers were extracted for both vibrational heating and homogeneous cooling regimes. The systems in question pose some conundrums, such as cooling rates larger that theoretically predicted or accumulation of kinetic energy in rotational DOF which is hard to observe in the experiment. Currently, the granular gas mixture of shorter and longer rods is under analysis. Our studies are funded within by the DLR projects VICKI, EVA-II, JACKS, and KORDYGA (50WM2252, 50WK2348, 50WM2340, and 50WM2242). [1] K. Harth et al., Rev. Lett., 120, 214301 (2018) [2] Puzyrev et al., npj Microgravity, 10, 36 (2024)

DY 21.4 Wed 10:15 H43

Force networks in granular experiments: From topology to dynamics — •Lou Kondic — Department of Mathematical Sciences, NJIT, Newark, NJ, USA

We will discuss force networks that spontaneously form in particulate-based systems. These networks, most commonly known as 'force chains' in granular systems, are dynamic structures of fundamental importance for revealing the underlying causes of many physical phenomena involved in the statics and dynamics of particulate-based systems. While these networks emerging from discrete element simulations have been analyzed extensively, the analysis of networks found in physical experiments is far less developed. The presentation will focus on applications of algebraic topology, particularly persistent homology (PH) to analysis of such networks. PH allows for a simplified representation of complex interaction fields in both two and three spatial dimensions in terms of persistent diagrams (PDs) that are essentially point clouds. These point clouds could be compared meaningfully, allowing for the analysis of the underlying systems' static and dynamic properties. The presentation will focus on applications of topological data analysis of such networks found in photoelastic experiments involving an intruder moving in a stick-slip fashion through a 2D granular domain. We will particularly focus on exploring the predictability potential of the considered topological measures.

DY 21.5 Wed 10:30 H43

Crystallization dynamics in a dense sphere system — •Frank Rietz and Matthias Schröter — Max Planck Institute for Dynamics and Self-Organization (MPIDS), Göttingen

When balls are thrown into a box and subsequently agitated, they tend to arrange themselves in a denser configuration, as observed in numerous experiments. However, a barrier is typically present at random close packing, which occupies approximately 64% of the available space. The spheres remain in their densest amorphous state and do not undergo a phase transition to a denser crystalline structure with a space-filling ratio of 74%. In our experiment, we successfully surmounted this barrier and observed the emergence of crystallization events from the disordered phase [1].

Initially, we observed the formation of groups of a few spheres that fluctuated between a disordered and a nucleated state. In rare instances when the balls remained in the ordered state, further investigation was conducted into their preceding conditions. This approach enables us to address the question of why the majority of precursors are not stable, while a few of them undergo growth to become part of the larger crystals of FCC and HCP structures that never dissolve.

[1] F. Rietz, C. Radin, H. L. Swinney, M. Schröter: Nucleation in sheared granular matter, Phys. Rev. Lett. 120, 055701 (2018)

DY 21.6 Wed 10:45 H43

Vibro-fluidized beds: A systematic dynamics study utilizing Diffusing Wave Spectroscopy — •Marlo Kunzner, Christopher Mayo, Matthias Sperl, and Jan Philipp Gabriel — Deutsches Zentrum für Luft- und Raumfahrt, Köln, Deutschland

Using a granular vibration fluidised bed, we demonstrate how our granular model system of polystyrene spheres becomes denser over time through different excitation amplitudes and how the heterogeneous dynamics of the system can be resolved with diffusing wave spectroscopy(DWS) measurements. We extract mean-square displacements from the DWS correlation functions of the sinusoidal excited system and model the excitation to extract the ballistic and diffusive time constants, as well as caging sizes, depending on applied acceleration and excitation time. At low excitations we observe a sub-diffusion power law behaviour of the MSD indicating potentially a glassy system.

DY 21.7 Wed 11:00 H43

Simulation of Spherical Particles as a Granular Gas in Microgravity: A Comparison with Experimental Results

— •Mahdieh Mohammadi[1], Torsten Trittel[1], Rau'l Cruz Hidalgo[2], Dmitry Puzyrev[3], Ralf Stannarius[1], and Kirsten Harth[1] — [1]Department of Engineering, Brandeburg University of Applied Sciences, Magdeburger Str. 50, 14770 Brandenburg an der Havel,Germany — [2]Departamento de Física y Matemática Aplicada, Facultad de Ciencias , Universidad de Navarra, Pamplona, Spain — [3]MTRM, Otto von Guericke University Magdeburg, Universitätsplatz 2, 39106 Magdeburg, Germany

Simulation of a Granular Gas of Frictional Spherical Particles in Microgravity: A Comparison with Experimental Results

We investigate dilute granular ensembles (granular gases) of rough spheres in Microgravity, both in experiment and simulation. The experiment examines the time scale (Haff time) for energy dissipation in an initially excited granular gas, the collision statistics, and the distribution of angular and translational velocities. We aim to determine how well the experimental results can be reproduced by a DEM simulation. A variety of criteria were tested, including different restitution coefficients. One goal of the simulation is to analyze the effect of different collision parameters on the statistical properties of a granular gas. Second, we aim demonstrate how the model can effectively replicate the experimental data, with a strong correlation between the translation energy in the model and experimental data.

We thank DLR for funding in grants 50WM2242 / 50WM2340.

DY 21.8 Wed 11:15 H43

Aerodynamic origin of aeolian mineral dust emission — Sandesh Kamath[1,2], Yaping Shao[2], and •Eric Parteli[1] — [1]Fakultät für Physik, Universität Duisburg-Essen — [2]Institut für Geophysik und Meteorologie, Universität zu Köln

Atmospheric dust aerosol particles exert a substantial impact on climate, radiation balance, and various other components of the Earth's system. However, state-of-the-art climate models rely on empiric parameterization schemes for the vertical dust flux at emission. While such schemes are derived from wind-tunnel simulations on flat granular beds, environmental soils are often characterized by a spatial distribution of non-erodible elements and crusts. Indeed, the vertical flux predicted by the various schemes often differs from observations by orders of magnitude. Here we develop a numerical tool for the particle-based simulation of wind-blown transport of granular particles in the atmospheric boundary layer. Our model accurately reproduces the observed minimal threshold wind shear velocity for direct fluid entrainment over the entire broad range of particle diameters from dust to gravel particles. However, we show that a topographic effect in polydisperse beds and soils with large non-erodible elements lowers the minimal threshold for dust entrainment substantially. This finding challenges our understanding that dust is mainly ejected at sand grain-bed collisions, rather than being directly entrained by wind. Our simulations show that dust can be emitted as single grains, as dust agglomerates, or coated on the surface of sand grains, depending on dust grain size.