# DY 25: Granular Matter / Contact Dynamics

Time: Wednesday 9:30–12:30 Location: H3

**Invited Talk** DY 25.1 Wed 9:30 H3

**Why the desert is not flat** — •Klaus Kroy — Institut für Theoretische Physik, Universität Leipzig, Brüderstraße 16, 04003 Leipzig

Windblown sand creates a distinct hierarchy of mobile landforms on Earth and other heavenly bodies [1], ranging from neat tapestries of ripples to vast fields of shifting dunes. I explain how they form, and what determines their characteristic shapes, sizes, and migration dynamics. This involves three crucial physical mechanisms: spontaneous turbulent symmetry breaking, breaking of scale invariance by an emergent mesoscale, and particle sorting. Collectively, they give rise to the notion of a forbidden wavelength gap that can only be inhabited by a peculiar structure, commonly known as megaripple but mechanistically better understood as as a mini-dune [2], which may be the predominant aeolian structure on Mars [3].

[1] A. G. Hayes: Dunes across the solar system, Science 360 (2018) 960.
[2] M. Lämmel, A. Meiwald, H. Yizhaq, H. Tsoar, I. Katra, and K. Kroy: Aeolian sand sorting and megaripple formation, Nature Physics 14 (2018) 759.
[3] D. C. Berman, M. R. Balme, J. R. Michalski, S. C. Clark, E. C. S. Joseph: High-resolution Investigations of Transverse Aeolian Ridges on Mars, Icarus 312 (2018) 247.

DY 25.2 Wed 10:00 H3

**Hydrodynamics versus charged fractals** — •Chamkor Singh and Marco Mazza — Max Planck Institute for Dynamics and Self-Organization (MPIDS), Am Faßberg 17, 37077, Göttingen, Germany

The growth of protoplanetary dust from sub-millimeter sized particles to much larger scales is not well understood. There is considerable debate about the role of electrostatic charging of grains in the aggregation process. Additional complexity arises due to the presence of complex hydrodynamic flow that couples to the aggregating grains. We study this growth process using massively parallel molecular dynamics simulations for the granular particles in combination with the hydrodynamic simulations for the interstitial flow. The results from a detailed cluster analysis are presented. Finally we propose an effective kinetic model for the charged grain aggregation inside interstitial flow.

DY 25.3 Wed 10:15 H3

**Non-equilibrium steady states, coexistence and criticality in driven quasi 2D granular matter** — •Thomas Schindler and Sebastian C. Kapfer — Institut für Theoretische Physik I, Universität Erlangen-Nürnberg, Staudtstraße 7, 91058 Erlangen

Non-equilibrium steady states of vibrated inelastic frictionless spheres are in quasi-two-dimensional confinement via molecular dynamics simulations are presented. The phase diagram in the density-amplitude plane exhibits a fluid-like disordered and an ordered phase with threefold symmetry, as well as phase coexistence between the two. Moreover, there is a square bilayer state which is connected to the fluid by BKTHNY-type two-step melting with an intermediate tetratic phase.

The critical behavior of the two continuous transitions is studied in detail. For the fluid-tetratic transition critical exponents of $\tilde{\gamma} = 1.73$, $\eta_4 = 0.25$, and $z = 2.05$ are obtained. The phase diagram topology is incompatible with any equilibrium free energy and features an anomalously diluted fluid in coexistence with the threefold cluster. A dynamical mechanism exists that brings about metastable traveling clusters and at the same time stable clusters with anisotropic shapes at low vibration amplitude.

DY 25.4 Wed 10:30 H3

**Extending Differential Dynamic Microscopy (DDM) to X-ray imaging** — •Manuel Baur and Matthias Schröter — Institute for Multiscale Simulation, FAU, Erlangen

We study a dense granular system in a water fluidized bed via X-ray radiography. The particles exhibit a 3D motion, which is not understood. Differential Dynamic Microscopy (DDM) is a well established technique to analyze the dynamics of dilute colloidal systems. We apply this method to X-ray imaging of a granular system. The physics behind the imaging is quite different; i.e. optical light scattering captured with a microscopy vs. X-ray attenuation according to Lambert-Beers law. We discuss to what extend this influences the analysis.

DY 25.5 Wed 10:45 H3

**Granular Dotriacontapoles** — Felix Braun, Stefan Hartung, •Ingo Rehberg, Reinhard Richter, and Andreas Weber — Universität Bayreuth

Granular matter is generally idealized as a material with pure contact interaction. Sometimes additional interactions have to be taken into account, e.g., for wet or polarizable granules. We present an experimental study of spherical particles [1] with dotriacontapole interaction.

[1] Dotriacontapoles - almost self-assembled. Stefan Hartung, Felix Sommer, Simeon Völkel, Johannes Schönke, Ingo Rehberg; arXiv:1809.08081; PRB, accepted.

DY 25.6 Wed 11:00 H3

**Estimation of 3D force chains for packings of soft, nearly frictionless hydrogels spheres** — •Diego Sancho Martínez[1], Ralf Stannarius[1], Ahmed Ashour[1], Torsten Trittel[1], Tilo Finger[1], Maja Illig[1], and Tamas Börzsönyi[2] — [1]Institute of Physics, Otto von Guericke University, Magdeburg, Germany — [2]Wigner Institute for Solid State Physics, Hungarian Academy of Sciences, Budapest, Hungary

Discharge of granular materials from hoppers has been extensively investigated in the past. Many factors affect the rheology of flow and discharge such as the shape of the hopper, the orifice geometry, or the characteristics of the granular material. We investigate soft and nearly frictionless hydrogels and compare them to hard spheres clogged in a 3D silo. By means of X-ray computed tomography, we determine the packing fractions and the contact numbers of soft and hard spheres. In addition, we estimate the force chains of hydrogel spheres randomly packed in a container. These forces were calculated as a function of the deformation induced in the granular material, the force chains form due to the increasing pressure with increasing fill high. The Janssen law is not effective for the soft and nearly frictionless materials.

**15 min. break**

DY 25.7 Wed 11:30 H3

**Dynamics of polygonal disks under vertical vibrations** — •Simeon Völkel and Kai Huang — Experimentalphysik V, Universität Bayreuth, 95440 Bayreuth, Germany

In order to elucidate the assembly of hexagonal disks into a rotator-crystal-like state upon vertical vibrations, we investigate experimentally the dynamics of a single disk under different confining conditions.

The probability distribution of the angular velocity is found to contain three peaks, one originating from clapping and two from rotation due to precession. Furthermore, the translational and rotational degrees of freedom are coupled.

The time evolution of the translational and rotational part of the kinetic energy within one vibration cycle exhibits a phase shift depending on the container height, eventually leading to a qualitative change of the particle movement. This indicates the 'micro-' origin of the dependence of the collective behavior on the vertical confinement.

DY 25.8 Wed 11:45 H3

**Structural similarity between dry and wet sphere packings** — •Matthias Schröter[1,2], Simon Weis[3], and Gerd Schröder-Turk[3,4,5] — [1]Institute for Multiscale Simulation, Friedrich-Alexander-Universität Erlangen-Nürnberg — [2]Max Planck Institute for Dynamics and Self-Organization, Göttingen — [3]Institut für Theoretische Physik I, Friedrich-Alexander-Universität Erlangen-Nürnberg — [4]Maths & Stats, School of Engineering and Information Technology, Murdoch University, Perth, Australia — [5]Applied Maths, Research School of Physical Sciences & Engin., Australian National Univ., Canberra, Australia

The mechanical properties of granular materials change significantly in the presence of a wetting liquid which creates capillary bridges between the particles. Here we demonstrate, using X-ray tomographies of dry and wet sphere packings, that this change in mechanical properties is not accompanyied by structural differences between the packings. We characterize the latter by the average numbers of contacts of each sphere $\langle Z \rangle$ and the shape isotropy $\langle \beta_0^{2,0} \rangle$ of the Voronoi cells of the particles. Additionally, we show that the number of liquid bridges per sphere $\langle B \rangle$ is approximately equal to $\langle Z \rangle + 2$, independent of the volume

fraction of the packing. These findings will be helpful in guiding the development of both particle-based models and continuum mechanical descriptions of wet granular matter.

DY 25.9 Wed 12:00 H3

**Numerical investigation of shear-induced incipient particle motion on regular substrates** — •Björn König[1], Othmane Aouane[1], Nikola Topic[2], Andreas Wierschem[2], and Jens Harting[1,3] — [1]Forschungszentrum Jülich GmbH, Helmholtz Institute Erlangen-Nürnberg for Renewable Energy (IEK-11), Nürnberg, Germany — [2]Institue of Fluid Mechanics, Friedrich-Alexander-Universtät Erlangen-Nürnberg (FAU), Erlangen, Germany — [3]Department of Applied Physics, Eindhoven University of Technology, Eindhoven, The Netherlands

Incipient motion of particles is important in different natural and industrial processes. The aim of this work is the numerical simulation of the motion of a single spherical particle placed on a fixed regular substrate bed subjected to a laminar shear flow. The bed is a monolayer of quadratically arranged spheres of the same size as the top particle. Varying the distance between the substrate particles provides different exposure degrees of the single sphere to the flow. The numerical framework utilizes the lattice Boltzmann method (LBM) for the flow field coupled with the discrete element method (DEM) to solve the particle dynamics.

We first determine the critical conditions for incipient particle motion. Critical conditions are characterized by the dimensionless Shields number, describing the ratio of acting stress to the effective particle weight. Second we study the displacement of the single sphere over the substrate at super-critical conditions. The outcomes of the numerical simulations are benchmarked against experimental results.

DY 25.10 Wed 12:15 H3

**Granular drag induced by oblique impact** — Valentin Dichtl, Felix Rech, and •Kai Huang — Experimentalphysik V, Universität Bayreuth, Bayreuth, Germany

Considering granular medium as a complex fluid with a finite yield stress, an object moving inside has to locally unjam and mobilize the surrounding particles in order to step forward. Consequently, granular drag depends strongly on the local rheological behavior. Using a recently developed bi-static radar system capable of tracking a metallic object with a diameter down to a few millimeters, we monitor the trajectory of a projectile penetrating obliquely into a granular medium and characterize the velocity dependent granular drag in both vertical (along gravity) and horizontal directions. Recent advances in this particle tracking technique and the possibility of using it as a local rheometer for granular media will be discussed.