DY 18: Granular Matter / Contact Dynamics

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

DY 18.1 Wed 9:30 ZEU 118

Onset of wall induced convection in vertically oscillated granular systems — •Andrea Fortini — Theoretische Physik II, Physikalisches Institut, Universität Bayreuth, Universitätsstraße 30, D-95447 Bayreuth, Germany

We investigate with two-dimensional computer simulations the onset of the wall-induced convection in vertically shaken granular matter. The convection is one of the major contributing mechanism responsible for the brazil nut effect, i.e. the rise of big particles in a container of small grains. We investigate the convective motion in relation to the dynamical phase diagram of monodispersed grains and show that the wall-induced convection occurs inside the "bouncing bed" region of the parameter space in which the granular bed behaves like a bouncing ball. We find that the onset of the convective motion is caused by the activation of slip mechanisms of the crystalline planes in the closed-packed granular bed. Furthermore, we explore the role of defects and grain boundaries in the onset of convection.

DY 18.2 Wed 9:45 ZEU 118

Emergent surface tension in driven granular media. — •James PD Clewett — Max Planck Institute for Dynamics and Self-Organization, Am Faßberg 17, 37077 Göttingen, Germany

A liquid-gas-like phase separation is observed in vertically vibrated granular media confined between two horizontal plates. Experiments and simulations were used to show that the coarsening dynamics are spinodal in nature, similar to a system undergoing curvature driven diffusion in the presence of a surface tension (model B). By studying quasi-2d, circular droplets we find behaviour consistent with Laplace's equation. Measurements of the pressure tensor in the interfacial region show that the surface tension is mainly due to an unexpected anisotropy in the kinetic energy components. This is in contrast to equilibrium thermodynamic systems, where surface tension arises due to attractive interactions between particles, or entropic considerations.

DY 18.3 Wed 10:00 ZEU 118

Equilibration of liquid morphologies in granulates with different wettability — •Marc Schaber[1], Mario Scheel[3], Martin Brinkmann[1,2], Marco DiMichiel[3], and Ralf Seemann[1,2] — [1]Experimental Physics, Saarland University, D-66041 Saarbrücken — [2]MPI for Dynamics and Self-Organization, D-37073 Göttingen — [3]European Synchrotron Radiation Facility, F-38000 Grenoble

When adding liquid to dry granulates of spherical beads, the liquid forms individual capillary bridges or a network of liquid morophologies depending on the amount of liquid and the wettability of the granules. Fairly monodisperse glass and basalt microspheres of different diameters are used as granules having small and large contact angle, respectively. By fluidizing the granulate, the packing geometry of the granules is temporarily changed and accordingly the liquid equilibrium distribution is destroyed. Using ultra-fast X-ray tomography we explore the time resolved re-distribution and re-organisation of liquid after stopping the fluidization and the evolution of all the bridges in the granulate. For poorly-wettable basalt beads no liquid redistribution was found. For wettable glass beads, however, a characteristic liquid equilibrium distribution is achieved after a characteristic time scale which depends on bead diameter, the viscosity and the amount of the added liquid.

DY 18.4 Wed 10:15 ZEU 118

Clustering of spinning wet granular hexagons in two dimensions — •Kai Huang and Ingo Rehberg — Experimentalphysik V, Universität Bayreuth, 95440 Bayreuth, Germany

In order to have a more general understanding of the dynamics of wet granular matter, a consideration to the shape of particles is necessary and of practical importance, since spherical particles rarely exist in nature. With a monolayer of vertical agitated wet granular particles with a hexagonal shape, we demonstrate experimentally how the shape of particles influence the collective motion. The particles are covered with a thin liquid film so that short ranged cohesive force may arise from the formation of capillary bridges between adjacent particles. In contast to agitated spherical particles, the hexagonal shaped particles exhibit a strong tendency to spin around its vertical axis, i.e., acting as self-propelled rotors. This type of self-propelled motion is found to hinder the binding of particles through the formation of capillary bridges and hence give rise to dramatically different dynamics towards clustering and crystallization of the particles. The time evolution toward various non-equilibrium steady states of such a granular system and a phase diagram of the steady state with varying agitation parameters and area fractions will be presented.

DY 18.5 Wed 10:30 ZEU 118

Drying in microfluidic cells as a model granular material — •Paolo Fantinel[1,2], Oshri Borgman[3], Ran Holtzman[3], and Lucas Goehring[1,2] — [1]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany — [2]Georg-August Universität, Göttingen, Germany — [3]Dept. of Soil and Water Sciences, Hebrew University, Rehovot, Israel

We study the drying of porous granular materials on a microscopic scale as to understand macroscopic mechanisms. We aim to develop a 2D pore-scale model through experiments. The long-term goal is to extend such class of models to 3D systems. Ours are microfluidic cells made of an array of pillars,representing the soil grains. The cells are open at one end to allow evaporation. The height is modifiable, as to vary pore elasticity, and we introduce different degrees of heterogeneity by randomly changing particle sizes and positions, as would happen in nature.

We fill the cells with a volatile fluid and watch them dry. At first evaporation happens mainly at the surface, then isolated clusters of fluid form. Through image analysis we find the pressure inside the pores by measuring the curvature of the air-water interfaces. We find a fractal dimension for the liquid-vapor interface of 1.4,close to what expected for percolation. We can also measure the variation in cluster volume, establishing the relative importance of flow through connected pores, thin-film flow and vapor diffusion.

Our experiments are being used together with simulations to establish a micro-scale model of drying in porous media.

DY 18.6 Wed 10:45 ZEU 118

Modeling of a Cohesive, Caking Powder in DEM Simulations — •Alexander Weuster and Dietrich E. Wolf — Uni DuE and CeNIDE, Duisburg, Germany

As the capacity of modern computers increases, it has become feasible to do simulations of bulk solids with particle numbers close to those in real experiments. Capturing every detail, however, remains a challenge, especially when dealing with non-spherical, cohesive particles and a large particle size distribution. Using the the example of μm-sized potassium chloride (KCl), we will present an approach to model a cohesive, caking powder in DEM-Simulations. By calibration of an idealized ensemble of spheres, we are able to reproduce the macroscopic flow properties of KCl observed in experiments.

15 min break

DY 18.7 Wed 11:15 ZEU 118

Observation of homogeneous crystallization in sphere packings — •Frank Rietz[1], Charles Radin[2], Harry L. Swinney[3], and Matthias Schröter[1] — [1]Max Planck Institute for Dynamics and Self-Organization (MPIDS), 37077 Goettingen, Germany — [2]University of Texas at Austin, Department of Mathematics — [3]University of Texas at Austin, Center for Nonlinear Dynamics

Sphere packings serve as a model for the microscopic structure of matter. Similar to atoms, spheres arrange in disordered and ordered phases. The densest disordered packing that is achievable for many experimental protocols is known as Random Close Packing. Frustration inhibits further increase of the density by crystallization. The theoretical picture of this barrier is still unclear.

In our experiment the sphere packing is driven by periodical tilting of the container side walls. Three-dimensional information is obtained by an index matching technique [1]. The initial disordered packing compacts and above the Random Close Packing density we observe homogenous crystallization of the interior spheres. We characterize this first order phase transition by measurement of local volumes, crystal growth rates and critical nucleus size. Investigation of local structural changes allows us to better understand the jamming at the Random Close Packing density.

[1] J. A. Dijksman et al., Rev. Sci. Instrum. 83, 011301 (2012).

DY 18.8 Wed 11:30 ZEU 118

Nearly-2D granular packings: A mechanical analogue to frustration in spin systems — •Kirsten Harth[1], Alexander Mauney[2], Frank Rietz[1], and Ralf Stannarius[1] — [1]Institut für Experimentelle Physik, Otto von Guericke Universität Magdeburg, Germany — [2]North Carolina State University, Raleigh, USA

Frustration of antiferromagnetic spins on a triangular lattice represents a fundamental problem in theoretical studies of magnetism, and is usually not experimentally observable on the microscale. Recently, an analogous problem has been investigated on an easily accessible length scale, using colloidal particles in a horizontal cell [1].

In granular materials, similar structures are easily prepared with glass spheres in a quasi-2D vertical cell, the cell thickness being slightly larger than the particle diameter. In nearly-hexagonal packings, some of the spheres attach to the front plate while others attach to the rear plate. By mapping the positions of the glass spheres experimentally, statistics of the degree of frustration are performed. Additionally, the influence of a magnetic field on the frustration statistics is mimicked by tilting the cell with respect to the normal in the gravitation field at well-defined angles, such that rear particles are energetically favoured.

[1] Y. Han, Y. Shokef, A. M. Alsayed, P. Yunker, T. C. Lubensky, Nature 7595, p. 898 (2008)

DY 18.9 Wed 11:45 ZEU 118

Ordering of Vertically Agitated Granular Rods in a Circular Confinement — •Thomas Müller, Ingo Rehberg, and Kai Huang — Experimentalphysik V, Universität Bayreuth, 95440 Bayreuth, Germany

Agitated granular matter can be considered as a non-equilibrium mode system for phase transitions and pattern formation. From this perspective, spherical particles have been frequently investigated in the past. However, in plenty of natural systems or industrial applications, one also has to deal with anisotropic particles like rice, medicine capsules, wood pellets etc.

Due to their anisotropy, granular rods share many properties with the well investigated rod-like liquid crystals, such as a transition from an isotropic to a nematic ordering phase. Although thermal energy can effectively mix liquid crystal molecules, continuous energy injection is needed for the self-organization of granular particles to compensate the energy dissipation. Under agitation, such dissipative systems can then evolve into ordered states or distinct patterns.

We study a single layer of monodisperse granular rods in a circular cavity which is vertically driven at various amplitude and frequency. By varying the packing fraction and the aspect ratio of the rods, we experimentally explore different orientational ordering phases and also compare with computer simulations.

DY 18.10 Wed 12:00 ZEU 118

MC-Simulation of Packings of Regular Tetrahedra — •Lukas Zwirner and Eckard Specht — Otto-von-Guericke Universität Magdeburg, Institut für Experimentelle Physik/Materialphysik

The problem of packing tetrahedra attracted much interest recently. For regular tetrahedra the densest known packing has a packing fraction of $\phi \approx 0.8563$. It is a periodic packing of double dimers (Chen et al., Discrete Comput. Geom. 44, p. 253 (2010)).

However, searching for a high packing fraction is not the only topic of interest, e. g. the wide field of quasi-crystals or behavior of granular matter are subject of current research.

We investigate the problem of packing identical, regular tetrahedra numerically by a pure geometrical approach. Hence, there is neither friction nor torques. The Monte-Carlo-method is applied to generate packings of regular tetrahedra using different protocols.

The packings are investigated with regard to their spatial structure (pair correlation function), their pairwise orientation and face-normal correlation.

DY 18.11 Wed 12:15 ZEU 118

Simulation of Current-Activated Pressure-Assisted Densification — •Sebastian Angst and Dietrich E. Wolf — Physik, Universität Duisurg-Essen

Cohesive particles usually form very porous agglomerates. They support loads up to a consolidation pressure, which increases with decreasing particle size. Compaction of nano-powders can therefore be very costly and time consuming. If the particles are electrically conducting, which is the case e.g. for novel nano-structured thermoelectric materials, the technique of current-activated pressure-assisted densification (CAPAD) turns out to have many advantages. Electrical power deposited locally as Joule heat lowers the consolidation pressure such that higher densities without much coarsening are obtained. We present a new model combining particle dynamics, calculated by molecular dynamic methods, with a network model including thermoelectric properties.

DY 18.12 Wed 12:30 ZEU 118

Self-Assembly of Spherical Magnets — •Igor Stanković[1], Lara Abou Khali[2], and René Messina[2] — [1]Scientifc Computing Laboratory, Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia — [2]Institut de Chimie, Physique et Materiaux (ICPM), Universite de Lorraine, 1 Bd. Arago, 57070 Metz, France

The self-assembly of spherical magnets is addressed theoretically. Minimal energy structures are obtained by optimization procedures as well as Monte Carlo computer simulations. Three typical shapes are obtained depending on the number of constitutive magnets N. In the regime of small N, chains are stable as dimers or trimers (i.e., $N \leq 3$), then rings become stable for ($4 \leq N \leq 13$) where dipole vectors adopt a vortex-like arrangement. A major finding concerns the stacking of rings as soon as N is large enough ($N \leq 14$). All the relevant predicted shapes are experimentally reproduced by manipulating commercial magnets.