DY 4: Granular Matter / Contact Dynamics Part I

Time: Monday 9:30–12:30 Location: BH-N 128

DY 4.1 Mon 9:30 BH-N 128

Vertically vibrated granular gas with van der Waals interactions — •Qiong Bai, James P. D. Clewett, Stephan Herminghaus, and Marco G. Mazza — Max Planck Institute for Dynamics and Self-Organization, Am Fassberg 17, 37077 Goettingen, Germany

Although a lot of research has focused on granular matter, as a non-equilibrium system granular matter is still a field full of unexplored static and dynamic phenomena. An important system is granular gases with macroscopic van der Waals interactions, which play a critical role in the generation process of asteroids.

Here, we study with MD simulation a vertically vibrated, 3D granular gas with van der Waals interactions between grains. As the driving amplitude and filling fraction vary, the system shows three main regimes: homogeneous, solid-gas coexistence and clustered. Moreover, when the system is in a solid-gas coexistence state, we find crystalline clusters inside the solid plug and the cluster size dramatically changes with the driving amplitude and filling fraction.

DY 4.2 Mon 9:45 BH-N 128

Ordering of Granular Rod Monolayers Driven Far from Thermodynamic Equilibrium — Thomas Müller[1], Daniel de las Heras[2], Ingo Rehberg[1], and •Kai Huang[1] — [1]Experimentalphysik V, Universität Bayreuth, D-95440 Bayreuth, Germany — [2]Theoretische Physik II, Universität Bayreuth, D-95440 Bayreuth, Germany

The orientational order of vertically agitated granular rod monolayers is investigated experimentally and compared with equilibrium Monte Carlo simulations and density functional theory. At sufficiently high density, short rods form a tetratic state and long rods form a uniaxial nematic state. The length-to-width ratio at which the order changes from tetratic to uniaxial is around 7.3 in both experiments and simulations. Such a comparison illustrates the universal aspects of the self-organization of rod-shaped particles across thermal and athermal systems.

DY 4.3 Mon 10:00 BH-N 128

About the adaptability of Edwards' theory to 2D granular assemblies — •Volker Becker and Klaus Kassner — Institut für theoretische Physik, Otto-von-Guericke-Universität Magdeburg, Germany

A possible approach for the statistical description of granular assemblies is Edwards' assumption that all blocked states which occupy the same volume are equally probable (Edwards, Physica A 157,1989). Other authors claimed that a similar approach where all states with the same stress are assumed as equally probable are more suited for developing a granular statistical mechanics, and Blumenfeld et al. (PRL 238001, 2012) argued that only a combined volume-stress ensemble is an appropriate basis for granular statistics.

We performed computer simulations using two dimensional polygonal particles excited periodically by two different protocols, excitation by "pulses of negative gravity" and excitation by "rotating gravity". The first protocol shows a non-monotonous dependency $\phi(g)$ of the mean volume fraction on the pulse strengths.

We used the overlapping histogram method in order to test whether or not the volume is described by a Boltzman-like distribution and to calculate the inverse compactivity, up to an additive constant. We found that the mean volume is a unique function of the granular temperature, independently of the protocol and of the branch in $\phi(g)$. However, this is not case for the mean stress, which can be different for the same value of compactivity (or the mean volume).

DY 4.4 Mon 10:15 BH-N 128

Packing of spheres in a flat container and geometrical frustration — Kirsten Harth and •Ralf Stannarius — Otto-von-Guericke-Universität Magdeburg

We study the packing of monodisperse spheres in a flat vertical box with cell gap slightly larger than the particle diameter. The particles form a nearly regular triangular lattice in the cell plane. The additional freedom of a displacement normal to the cell plane places them either at the front or rear cell plate, leading to a denser arrangement in the cell plane, but at the same time to frustrated states (two of three neighboring beads have to occupy the same cell wall). Analogies to order in antiferroelectric Ising spin systems on a triangular lattice and to colloidal assemblies in thin layers are evident. We analyse the packing statistics and compare them to Monte Carlo simulations. By tilting the container from the vertical, we can modify the relative occupation numbers of front and back sites, mimicking an external field similar to magnetic fields in spin systems. The experiment offers both insights in the influence of geometrical constraints on random packing, and a descriptive example of frustrated ordering.

DY 4.5 Mon 10:30 BH-N 128

The mechanism of pattern coarsening of granular mixtures in rotating drums — •Tilo Finger[1], Ralf Stannarius[1], and Matthias Schröter[2] — [1]Otto-von-Guericke-Universität Magdeburg — [2]MPI für Dynamik und Selbstorganisation Göttingen

Three fundamental segregation and pattern formation processes have been reported in granular mixtures in a rotating cylindrical drum: radial segregation, axial banding and coarsening of the band pattern. While for the first effect the mechanism is well understood and for the second effect several models have been proposed, the coarsening mechanism remained unexplained so far. We reveal the mechanism for the well-known unidirectional flow between neighboring bands in an axially segregated pattern. A process of microsegregation inside each band of small particles is reported, which was so far unrecognized. On the basis of our findings, the stability of individual bands can be easily controlled by minor alternations of their composition. We suggest viable hypotheses to explain the driving force behind the flow.

DY 4.6 Mon 10:45 BH-N 128

Mechanical stability of random packings of spherocylinders — •Pascal Wieland and Claus Heussinger — Georg-August-Universität Göttingen

We simulate random packings of soft, frictionless spherocylinders over a wide range of aspect ratios ($10 \leq \alpha \leq 80$) in the vicinity of the jamming point. In our studies we focus on the stability of these packings, especially the relation between average number of contacts $\langle Z \rangle$, aspect ratio α and volume fraction ϕ. Comparison of our results with previous works shows deviations and we try to extend the model used in previous works. The results are compared with experiments done using Spaghettinis.

15 min. break

DY 4.7 Mon 11:15 BH-N 128

Cooling of 3D Granular Gases: Microgravity Experiments — •Kirsten Harth, Torsten Trittel, Sandra Wegner, Kathrin May, and Ralf Stannarius — Institut für Experimentelle Physik, Otto von Guericke Universität Magdeburg

Granular gases represent one of the simplest systems for investigations of non-equilibrium statistical physics, yet they are still poorly understood. They represent ensembles of macroscopic grains interacting through inelastic collisions. The use of elongated grains facilitates the realization of 3D experiments beyond the Knudsen regime. We recently found non-gaussian velocity distributions and a violation of the equipartition of kinetic energy, i.e. rotational degrees of freedom are underexcited [1]. With a special preparation technique, we can study such systems during the short microgravity period offered by drop towers. We present the first experimental study based on 3D data, with focus on the initial period of granular cooling. Experiments were conducted at the ZARM drop tower in Bremen, with approx. 9.2 of microgravity. We analyze and compare velocity and density distributions as well as the decay of kinetic energy in different experimental realizations.

[1] K. Harth, U. Kornek, T. Trittel, U. Strachauer, S. Höme, K. Will, R. Stannarius, Phys. Rev. Lett. 110 144102 (2013)

DY 4.8 Mon 11:30 BH-N 128

Maxwell Construction for Nonequilibrium Steady-State Phase Separation in Granular Matter — •James Clewett — Max Planck Institute for Self Organisation, Bunsenstrasse, Goettingen 37077

Experiments and computer simulations are carried out to investigate phase separation in a granular gas under external vibration in a large sample cell. The densities of the dilute and the dense phase are found to follow a lever rule, suggesting an equation of state. We show that this equation of state, which exhibits a non-monotonic pressure-volume characteristic, P(v), can be obtained from simulations of a small cell. A Maxwell construction is found to predict both the coexisting pressure and binodal densities remarkably well, despite the fact that P(v) is not an isotherm. Although the system is far from equilibrium and energy conservation is strongly violated, we can derive this finding from an energy minimization argument of fluctuating currents.

DY 4.9 Mon 11:45 BH-N 128

Changing friction in ellipsoid packings — •Simon J.A. Weis[1], Fabian M. Schaller[1,2], Gerd E. Schröder-Turk[1], and Matthias Schröter[2] — [1]Theoretische Physik, FAU Erlangen, Germany — [2]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany

Friction is an important parameter for the stability of granular packings. We examine packings of ellipsoids- and spheres with different friction coefficients and aspect ratios. Interparticle friction is changed by grinding the particles in a rotating drum.

Various packings are prepared and structural properties like Voronoi cell shapes, mean and local contact numbers and packing fractions as well as angle distributions and -correlations are studied by means of Xray-tomography. Data for spheres is compared to numerical data from DEM simulations.

Additionally mechanical properties of packings are measured within a shearcell setup and correlated to the structural results to contribute to a better understanding of stability.

DY 4.10 Mon 12:00 BH-N 128

nonaffine deformation and mechanical response of dense granular materials — •m reza shaebani[1] and jens boberski[2] — [1]Department of Theoretical Physics, Saarland University, Saarbrucken, Germany — [2]Department of Physics, University of Duisburg-Essen, Duisburg, Germany

The mechanical response of granular materials considerably differs from that of an ordinary elastic solid. Understanding the behavior, besides the scientific interest, has important practical applications. The emerging nonlinear relation between stress and strain can be attributed e.g. to the presence of disorder, nonlinearity of the contact force law, and Coulomb friction threshold. However, even in the absence of these elements in the nature of the interactions and the environment, the nonlinear elastic response may still exist because of the unilateral interactions in dry granular systems. Opening of a contact terminates the local transmission of restoring or frictional forces, while formation of a contact provides new possibilities for it. We first show how taking the unilateral interparticle interactions into account would improve the analytical predictions for the mechanical response, and compare the results with simulations. We attribute the remaining discrepancy to the contribution of nonaffine motions during the deformation process, and discuss the possible ways to include these motions in the stochastic modeling of stress transmission in granular media. We also clarify how the evolution of the probability distributions of contact forces deviate from the affine assumption during isotropic compression or shear deformation processes.

DY 4.11 Mon 12:15 BH-N 128

Heterogeneity of local mechanical properties in binary granular systems — •Sebastian Pitikaris, Peidong Yu, and Matthias Sperl — DLR Institute of Materials Physics in Space, Cologne, Germany

We investigate the critical scaling behavior of the contact number above the critical packing fraction in binary mixtures. We use different particle concentrations and strongly varying size ratios to see whether there is an influence to the scaling exponent. The results can be compared to theoretical predictions.

From stress-birefringent images we can precisely identify rattlers and moreover reconstruct force distributions and thus compute the local shear modulus. The results can be compared to recent simulation work which predicts a heterogeneous shear modulus in disordered systems.