DY 31: Granular matter / contact dynamics II

Time: Friday 10:15–13:00 Location: H2

DY 31.1 Fri 10:15 H2

About contact models for granular matter — •Stefan Luding — Particle Technology, Nanostructured Materials, DelftChemTech, TUDelft, Julianalaan 136, 2628 BL Delft, NL

In adhesive granular matter, phenomena like cohesion, agglomeration, sintering, compaction and fracture can be observed. The basic ingredient for the discrete modeling of granular matter is the contact model that enters the Molecular Dynamics like simulation algorithm. A contact model is presented that does not only allow for simulation of rather large granular matter in the milli-meter range, but also for much finer particles in the micro-meter range or even smaller. Besides dissipation and elasticity, the contact model involves plastic deformation, contact-adhesion, tangential friction, and rolling-resistance as well as torque-resistance. Agglomeration, pressure-sintering and tensile tests can now be examined with a single contact model.

DY 31.2 Fri 10:30 H2

Multiscale Simulations of Powder Sintering by Discrete Element Modeling — •Andreas Wonisch, Torsten Kraft, Michael Moseler, and Hermann Riedel — Fraunhofer Institute for Mechanics of Materials, Freiburg, Germany

In powder technology bulk materials are created from a huge number of particles that are first compacted and then bonded together by sintering. Sintering is activated by heating the powder at a high temperature below the melting point and leads to densification and grain growth. The driving force for this phenomenon is the surface energy of the grains. In order to better understand how the structure and dynamics on the grain scale affect macroscopic sintering behavior the discrete element method (DEM) is applied. The simulation scheme is based on a (random) aggregate of particles and takes mesoscopic properties like particle sizes, particle distribution, rotation and rearrangement into account. Appropriate pair forces between particles have been derived to simulate solid-state and liquid-state sintering where an additional liquid phase enhances the densification rate by rearrangement of grains. We show how rearrangement and rotation affects macroscopic sintering properties like densification rate and viscosity. We also demonstrate that certain kinds of particle configurations and boundary conditions lead to crack formation and anisotropic sintering behavior.

DY 31.3 Fri 10:45 H2

Impedance Spectra of Numerically Generated Particle Setups — •Dominik Schwesig and Dietrich Wolf — Universität Duisburg-Essen

We use the Contact Dynamic Method to generate the particle c onfiguration of a cohesive powder in a cylinder for different applied stresses, as done in experiments for nanopowders. We simulate the complex resistance of these configurations with a classic circuit network for a wide range of frequncies and compare these spectra with a simple model for the current network in these powders.

DY 31.4 Fri 11:00 H2

Translation and Rotation are correlated in Granular Gases — •Thorsten Poeschel[1], Nikolai Brilliantov[2], Till Kranz[3], and Annette Zippelius[3] — [1]Charité, Augustenburger Platz 1, 13353 Berlin — [2]Institut für Physik, Universität Potsdam, Am Neuen Palais 10, 14469 Potsdam — [3]Institut für Theoretische Physik, Universität Göttingen, Friedrich-Hund-Platz 1, 37073 Göttingen

In a granular gas of rough spherical particles the axis of rotation of the particles is correlated with the translational velocity of the particles. The average relative orientation of angular and linear velocities depends on the coefficients of restitution which characterize the dissipative nature of the collision. We derive a theory for these correlations and validate it with numerical simulations for a wide range of coefficients of normal and tangential restitution. Surprisingly, even for vanishinlgy small roughness, there are *macroscopic* correlations of the particles. Therefore, granular gases of *almost* smooth particles behave very different from gases of smooth particles, that is, the limit of smooth spheres does not exist.

Reference: cond-mat/0609213

DY 31.5 Fri 11:15 H2

Macroscopic stress and strain distributions in sand piles — •Pradip Roul and Klaus Kassner — Institut für Theoretische Physik, Otto-von-Guericke-Universität Magdeburg, Postfach 4120, D-39016 Magdeburg

The stress distribution under a sand pile sometimes exhibits unusual features. Depending on characteristics such as the size distribution of grains but also the construction history of the aggregate, the pressure distribution may display a minimum or a maximum under the tip of the heap, with the former behaviour appearing counterintuitive. We performed numerical simulations generating two-dimensional "sand piles" from several thousand convex polygonal particles with varying shapes, sizes and corner numbers, using a discrete element approach based on soft particles. The pressure distribution regularly has a minimum under piles poured from a point source but does not show one, if the grains are poured from a line source. Calculations of the macroscopically averaged stress and strain tensors inside granular aggregates will be presented. Stress distributions are compared with the elasto-plastic theory of Cantelaube et al. It turns out that this theory describes the overall behaviour of the simulated sand piles well, if the relative size of the elastic and plastic regions is considered a free parameter. The prediction of this size itself by the theory is inaccurate.

DY 31.6 Fri 11:30 H2

The hopping ball: a common measurement method for the coefficient of restitution revisited — •Thomas Schwager[1], Christof Krülle[2], and Thorsten Pöschel[1] — [1]Charite, Augustenburger Platz 1, 13353 Berlin — [2]Experimentalphysik V, Universität Bayreuth, D-95440 Bayreuth

The coefficient of restitution is the central characteristics of the damping properties of granular material. One common way to measure this coefficient is to let a sphere fall on a rigid plate and measure the time interval between successive collisions. These measurements, however, are afflicted with intense stochastic fluctuations which drastically increase towards lower impact velocities – rendering the results problematic for the most interesting case of slow impact. As an added puzzle the distribution of the variations is non-Gaussian. These experimental results put the use of a deterministic coefficient of restitution in question. We present here a theoretical model of the particles which is in quantitative agreement with the experiment and which allows to shed light on the mechanism causing the stochastic variations. This in turn allows to extract useful information for the case of slow impact. Based on this model we will present a damping model which incorporates the observed statistical properties of the particle collisions. The consequences of this model for the theory of granular gases is discussed.

DY 31.7 Fri 11:45 H2

Axial transport of granular materials in a rotating drum — Khan Zeina S.[1] and •Morris Stephen W.[2] — [1]Max Plank Institute for Dynamics and Self-Organization, Goettingen, Germany — [2]University of Toronto, Department of Physics, Toronto, Canada

Bidisperse granular mixtures rapidly segregate by size when tumbled in a partially filled horizontal rotating drum. The smaller grains move radially towards the axis of rotation and form a buried radial core. On a longer time scale, modulations of the radial core may grow into axial bands. Using a narrow pulse of the smaller component as an initial condition, we observe that the axial transport of the radial core is a subdiffusive front advencement process. By colouring some of the larger grains, we also find that the mixing and axial transport is subdiffusive. We also report on the effects of changing the relative grain size and drum diameter on the axial transport of grains.

DY 31.8 Fri 12:00 H2

Segregation and convection of granular mixtures in a rotating Hele-Shaw cell at high fill levels — •Frank Rietz and Ralf Stannarius — Otto-von-Guericke Universität Magdeburg, Fakultät für Naturwissenschaften, Institut für Experimentelle Physik, Abteilung Nichtlineare Phänomene

We describe experimentally the segregation and pattern formations in a granular medium that is almost densely packed in a flat container. The experiment is inspired by theoretical work of Awazu [1]. The container is rotated around a horizontal axis at rates of a few rotations per minute. The granulate is a bimodal glass bead mixture. Our experimental results are qualitatively completely different from observations in a loosely packed container, where fluidization of the material leads to the formation of regular segregation stripes, like they are commonly found in rotating drums. Instead, we observe slow convection rolls that are accompanied by and decorated by a segregation of the mixture. 'Conventional' axial stripe patterns are observable for fill levels below 95% tapped volume. At fill levels above 95%, the granulate is nearly jammed and the mobility of particles almost inhibited. Convection modes develop with wave numbers related to cell height. The velocity of these regular convection motion decreases when the initial fill level approaches 100%.

[1] Phys. Rev. Lett. 84, 4585, 2000

DY 31.9 Fri 12:15 H2

Lateral segregation of bidisperse mixtures — •Michael Heckel, Andreas Götzendorfer, Christof Krülle und Ingo Rehberg — Experimentalphysik V, Universität Bayreuth, D-95440 Bayreuth, Germany

The understanding of the behaviour of vibrated granular matter is important because many industrial processes rely on mixed multicomponent substances. In the last years 'granulodynamics', i.e. the physics of granular media, has attracted the interest of physicists as well. In our experiments we study a binary mixture of spheres with different sizes in a circular vibrated environment on an especially designed vibratory conveyor [1]. Above a threshold frequency of the excitation the bigger particles move to the top of the granulate similar to the Brazilnut effect (BNE). If a second threshold frequency is exceeded another separation begins to dominate which can be seen as well-separated monodisperse domains in the vibrated bed. This reminds to phenomena known for purely horizontally shaken binary granular mixtures [2]. By increasing the shaker frequency even further a final state can be achieved where both particle species are separated completely in two distinct domains.

[1] M. Rouijaa, C. Krülle, I. Rehberg, R. Grochowski und P. Walzel, Transportverhalten und Strukturbildung granularer Materie auf Schwingförderern, Chemie Ingenieur Technik 76, 62 (2004)

[2] P.M. Reis and T. Mullin, Granular segregation as a critical phenomenon, Phys. Rev. Lett. 89, 244301 (2002)

DY 31.10 Fri 12:30 H2

Binary mixtures of inelastic hard spheres — •Wolf Till Kranz, Hildegard Uecker, and Annette Zippelius — Institute of Theoretical Physics, University of Göttingen, Germany

Analyzing the homogeneous cooling state of rarefied binary mixtures of inelastic hard spheres it is found that in general the species' temperatures do *not* evolve towards a common value. Nevertheless the temperature *ratio* becomes stationary within a few collisions per particle. In order to better understand this surprising effect we consider a simple model with a constant coefficient of restitution and derive a kinetic theory for the granular temperatures. The validity of the model is assessed by comparison with MD-Simulations. We present an argument that makes the source of and the conditions for the non-equipartition particularly transparent. Finally we will show how the above results can be generalized to mixtures with an arbitrary number of components in a straight forward manner.

DY 31.11 Fri 12:45 H2

Behaviour of Granular Media under Reduced Gravity — •Antje Brucks[1] and Jürgen Blum[2] — [1]Zentrum für angewandte Raumfahrttechnologie und Mikrogravitation, Am Fallturm, 28359 Bremen — [2]Institut für Geophysik und extraterrestische Physik, Technische Universität zu Braunschweig, Mendelssohnstr. 3, 38106 Braunschweig

Most granular surface flows are driven by gravity. Our understanding of such shear flows is much based on Earth-bound observations. Yet, pictures from Mars for example give rise to discussions on how strong the influence of ambient conditions such as air pressure and liquid lubricants in combination with reduced gravity are on the flow behaviour.

We investigated the effect of the reduction of the gravitational acceleration on the granular flow behaviour. The experiments were performed under microgravity conditions in the Bremen Drop Tower and were using a slowly rotating centrifuge for simulating low-gravity environments.

In our experiments, we used two flat (quasi-2D) sand glasses, a rotating tumbler and a somewhat larger box to resemble different aspects of flowing and avalanching granular materials as a function of g-levels between 1 g_0 and 0.01 g_0. We find that static and dynamic angle of repose increase with decreasing g-level in accordance to former investigations (Klein and White, AIAA J. 28(10),1701-1702 (1988)). However, we also find a lower limit where the cohesive properties start to dominate and prevent flow.