DY 9: Granular Matter/ Contact Dynamics I

Time: Tuesday 10:00–12:15 Location: H47

DY 9.1 Tue 10:00 H47

Is random close packing of spheres well defined? — •Frank Rietz[1], Ralf Stannarius[1], Charles Radin[2], Harry L. Swinney[2], and Matthias Schröter[3] — [1]Univ. of Magdeburg — [2]Univ. of Texas at Austin — [3]MPI for Dynamics and Self-Organization Göttingen

The name random close packing refers to the experimental observation that some ways of packing of monodisperse beads (like vertical vibration or sedimentation) can't exceed a volume fraction of ≈64%. There are several competing theories for this phenomenon [1-3]. However, it is possible to surpass the random close packing limit by cyclic shearing [4]. We investigate the three-dimensional distribution of particles in such a shear cell. Index matching of the surrounding liquid provides access to the interior of the granular bed. A laser sheet is scanned through the sample and by adding a fluorescent dye to the liquid we can determine the particle positions. The experiment starts at packing fractions well below random close packing. After a few thousand cycles packing fractions above 64% are achieved. By means of the Voronoi cells we characterize the local packing densities and measure order parameters around the onset of random close packing. This allows us to comment on the question if random close packing is well defined.

[1] Torquato *et al.*; Phys. Rev. Lett. **84**, 2064 (2000). [2] Kamien & Liu; Phys. Rev. Lett. **99**, 155501 (2007). [3] Radin; J. Stat. Phys. **131**, 567 (2008). [4] Nicolas *et al.*; Eur. Phys. J. E **3**, 309 (2000).

DY 9.2 Tue 10:15 H47

Random packings of spheres - Is there a limit on being loose? — •Matthias Schröter[1], Melissa Jerkins[2], and Harry L. Swinney[2] — [1]MPI for Dynamics and Self-Organization, Göttingen — [2]Center for Nonlinear Dynamics, UT Austin

A granular solid is defined by a finite yield stress; with decreasing volume fraction this yield stress vanishes and the sample turns into a granular fluid. The nature of this solid-liquid transition is still debatted. We will join the discussion by presenting experimental data how pressure, friction [1] and particle shape influence the phase boundary.

[1] Jerkins *et al.*, Phys. Rev. Lett. **101**, 018301 (2008)

DY 9.3 Tue 10:30 H47

Velocity Stratification through the Depth in Rapid Shear Flows of Granular Materials — •Birte Domnik[1], Christian Kröner[1], and Shiva P. Pudasaini[1,2] — [1]Steinmann Institut, Universität Bonn — [2]School of Science, Kathmandu University, Nepal

Appropriate rheology and boundary conditions are required in order to properly determine the dynamics of flow and the impact pressure induced by geophysical and industrial mass flows such as avalanches, debris flows and flow of granular materials. For simulations of ideal fluid, e.g., water, the no-slip is a generally accepted boundary condition which leads to reasonable results. However, it is observed in experiments and in the field that in rapid flow of granular material down the slopes, even the lowest particle layer in contact with the bottom boundary moves with a non-zero and non-trivial velocity. As the material friction substantially influences the flow velocities and also the depth profile an appropriate modelling of the boundary condition is important. In this talk, we present a new continuum mechanical model for rapid motion of granular material down slopes. Possible boundary conditions at the bottom like no-slip, free-slip and, in particular, enhanced approaches will be discussed. In the enhanced approach the bottom velocity can also depend on the bottom pressure. The simulation results demonstrate the applicability of the new model equations, particularly, in the regions where the strong shearing through the depth develops during the motion of the granular mass down the slope.

DY 9.4 Tue 10:45 H47

A Lattice Model with Fragmentation and Reagglomeration — •Alexander Weuster, Lothar Brendel, and Dietrich E. Wolf — Universität Duisburg-Essen, Fachbereich Physik and CeNIDE, 47048 Duisburg, Germany

Van der Waals forces play a major role in the formation-process of uncharged nanoparticles, since they exceed other forces, such as gravity. Agglomerates of ultra-fine cohesive particles, often referred to as nanopowders, can reach porosities up to 98 %. In fact, the porosity of a nanopowder plays a key-role in industrial application e.g. gas sensors, catalysts and diesel soot traps.

Aerosol aggregation processes produce fractal clusters, which increase, when deposited, the porosity of a nanopowder, in contrast to single particle deposition processes (Mädler et al. 2006). A new algorithm to create such a fractally substructured nanopowder was proposed by Schwager, Wolf and Pöschel(2008). Based on this work, we present a lattice model to generate such nanoparticle agglomerates in two and three dimensions. Fragmentation is done by a sieving procedure with a prescribed mesh size, followed by a ballistic deposition. Continous fragmentation and reagglomeration lead to a steady state configuration with a fractal substructure. By tuning the mesh size, the model is capable of producing agglomerates of arbitrarily high porosity. Results for fractal dimension, mass-distribution of the fragmentation process and scaling-relations are discussed.

DY 9.5 Tue 11:00 H47

Precursors of failure in granular systems — •Philipp Welker[1] and Sean McNamara[2] — [1]Institut für Computerphysik, Universität Stuttgart, Germany — [2]Institut de Physique de Rennes, Université de Rennes I, France

We study numerical simulations of large ($N \approx 10^4$) two-dimensional quasi-static granular assemblies subjected to a slowly increasing deviator stress ("biaxial test"). We report some peculiarities in the behavior of these packings that have not yet been adressed. The number of sliding contacts M_s is not necessarily related to stability: at approximatley half the peak stress, the increase of M_s slows down, a plateau develops, and a decrease follows.

The spatial organization of sliding contacts also changes: the formerly uniformly distributed sliding contacts become concentrated in certain regions in the second half of the simulation. This suggests that the loss of homogeneity occurs well before the appearance of shear bands. During the same period, events appear where M_s drops suddenly, and then rapidly recovers. We show that these events are in fact local re-arrangements in the packing, and that they are triggered by an instability. These events become more frequent as failure is approached. For these two reasons, these events are similar to the precursors recently observed in both numerical [1] and experimental [2], [3] studies of avalanches.

[1] L. Staron et al., *Phys. Rev. Lett.*, **89**, 204302 (2002).
[2] T. Scheller et al., *Phys. Rev. E*, **74**, 031311 (2006).
[3] M.A. Aguirre et al., *Phys. Rev. E*, **73**, 041307 (2006).

DY 9.6 Tue 11:15 H47

Temperature-induced liquid bridges — •Christoph Gögelein, Martin Brinkmann, Matthias Schröter, and Stephan Herminghaus — MPI für Dynamik und Selbstorganisation, Bunsenstr. 10, 37073 Göttingen

We all now that if we add a small amount of water to a heap of sand, the medium becomes paste-like since some of the grains get connected by liquid bridges. These bridges act as little springs between neighbouring particles stiffening the material. With wet sand, we can easily sculpture, for example, a sand castle [1]. We use a non-Brownian suspension of micrometer-large glass spheres dissolved in a critical binary liquid mixture to study the the physical properties of wet and dry granular matter. The suspending water-lutidine mixture exhibits a lower critical point leading to a phase separation slightly above ambient temperature. Within the two-phase region the water-rich phase wets the glass spheres and liquid bridges are formed between close-by particles. Thus, we can switch the bridges on by increasing temperature. We observe the temperature-induced formation of liquid bridges using a confocal microscope and calculate the cohesive force from bright field images.

[1] M. Scheel, et al., Nature Materials 7, 174 (2008)

DY 9.7 Tue 11:30 H47

Compressible kinematic modeling — •Claas Bierwisch and Michael Moseler — Fraunhofer-Institut für Werkstoffmechanik IWM, Wöhlerstr. 11, 79108 Freiburg

Granular discharge from a hopper through a slit orifice is studied using discrete element method simulations. A common continuum approach to describe the velocity field is given by kinematic modeling. This method is refined by considering volume fraction variations within the

flowing granular material. A relationship between the local volume fraction and a parameter which couples the horizontal and vertical velocity component was discovered. Considerable increase in accuracy is demonstrated by using this relationship in combination with the proposed compressible kinematic modeling.

DY 9.8 Tue 11:45 H47

Self-assembled granular walkers — •Zeina Khan[1], Audrey Steinberger[2], Ralf Seemann[1,3], and Stephan Herminghaus[1] — [1]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany — [2]Laboratoire de Physique, Ecole Normale Supérieure de Lyon, Lyon, France — [3]Experimental Physics, Saarland University, Saarbrücken, Germany

We have observed that when a bi-disperse mixture of glass beads is moistened by a fluid and shaken sinusoidally in a vertical container, small clusters of beads take off from the surface of the pile and rapidly climb up the container walls against gravity. These self-organized clusters are held together and against the wall by liquid capillary bridges, and are led by one large grain with one or more small grains trailing behind. When similar clusters are placed on a horizontally vibrating substrate they self-align and travel horizontally along the axis of vibration with a ratchet-like motion. We report on properties of this novel system, such as the clusters' speed as a function of the asymmetry of the structure and the driving acceleration. We also present a model that accounts for the observed behavior.

DY 9.9 Tue 12:00 H47

On the dynamics of cartoon dunes — •Christopher Groh[1], Ingo Rehberg[1], and Christof A. Krülle[1,2] — [1]Experimentalphysik V, Universität Bayreuth, D-95440 Bayreuth, Germany — [2]Fakultät für Maschinenbau und Mechatronik, Hochschule Karlsruhe - Technik und Wirtschaft, D-76133 Karlsruhe, Germany

The spatio-temporal evolution of a downsized model for a barchan dune is investigated experimentally in a narrow water flow channel. We observe a rapid transition from the initial configuration to a steady-state dune with constant mass, shape, velocity, and packing fraction. The development towards the dune attractor is shown on the basis of four different starting configurations. The shape of the attractor exhibits all characteristic features of barchan dunes found in nature, namely a gently inclined windward (upstream) side, crest, brink, and steep lee (downstream) side. The migration velocity is reciprocal to the length of the dune and reciprocal to the square root of the value of its mass. The velocity scaling and the shape of the barchan dune is independent of the particle diameter. For small dunes we find significant deviations from a fixed height-length aspect ratio. Moreover, a particle tracking method reveals that the migration speed of the model dune is one order of magnitude slower than that of the individual particles. In particular, the erosion rate consists of comparable contributions from low energy (creeping) and high energy (saltating) particles. Finally, it is shown that the velocity field of the saltating particles is comparable to the velocity field of the driving fluid.