DY 18: Granular matter / contact dynamics

Time: Wednesday 16:15–18:45 Location: HÜL 386

DY 18.1 Wed 16:15 HÜL 386

Quasistatic rheology at random close packing — •Claus Heussinger and Jean-Louis Barrat — Laboratoire de Physique de la Matière Condensée et Nanostructures Université Lyon 1, France

We report results of quasistatic shear simulations of athermal packings of frictionless elastic particles. We focus on densities at random close packing, where the system undergoes the "jamming" transition from a fluid to a solid state.

Previous studies have either concentrated on the linear elastic properties in the solid phase (development of "soft modes" under decompression, O'Hern PRE 2003), or on the flow properties of the fluid (e.g. Olson PRL 2007).

In contrast, the quasi-static method allows us to discuss both aspects at the same time as the simulation probes the borderline between fluid and solid phase – by construction it follows the yield-stress line of the material. The emerging coexistence of flowing and jammed states allows us to gain novel insights into the nature of the jamming transition.

DY 18.2 Wed 16:30 HÜL 386

Trigger of failure in granular assemblies — •Philipp Welker[1] and Sean McNamara[2] — [1]Institut für Computerphysik, Universität Stuttgart, 70569 Stuttgart, Germany — [2]GMCM, Institut de Physique de Rennes, Université de Rennes I, 35042 Rennes cedex, France

We investigate the mechanisms that trigger the collapse of assemblies of polydisperse granular media subjected to an increasing deviatoric stress. The DEM simulations in two dimensions are evaluated by use of the stiffness matrix.

It is always possible to identify a contact status change that triggers the collapse of the packing. This contact status change almost always causes, in small assemblies, a mechanical instability, or a motion with neutral stability. In a few cases, the status change provokes an oscillation, and a second status change following shortly thereafter introduces an instability. This is when failure happens, and the kinetic energy rises exponentially. In larger assemblies, motions with neutral stability become less frequent, while vibrations frequently appear.

We will explain the different trigger mechanisms and show how they depend on system size. Furthermore, we investigate the sources of energy that drive failure.

DY 18.3 Wed 16:45 HÜL 386

Theoretical Model of Avalanche Motion — •Birte Domnik, Christian Kröner, and Shiva P. Pudasaini — Steinmann Institut,Universität Bonn, Germany

A continuum model for rapid motion of granular material is presented, which provides both the geometry (height) and the velocity field of the granular flow. The knowledge of the motion and rheology of granular materials is needed in the area of snow avalanche hazard research in order to determine the regions at risk and the impact power of avalanches on defense structures. First a depth-integrated model [1] based on the Savage-Hutter model is presented, which is useful in regions where the flow is almost plane and vertical momentum transfer can be neglected. The main challenge in modelling a complete three dimensional flow is to find an appropriate description of the stresses in the material. Therefore, different stress models are implemented into a not depth-integrated flow model. To reduce the computing time the not depth-integrated and the depth integrated model will be coupled.
[1] S. P. Pudasaini, Avalanche Dynamics, Springer-Verlag,Berlin, 2007

DY 18.4 Wed 17:00 HÜL 386

Long-Time Tails and Cage Effect in Driven Granular Fluids — •Andrea Fiege[1], Timo Aspelmeier[1], and Annette Zippelius[1,2] — [1]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany — [2]Institute of Theoretical Physics, University of Göttingen, Germany

We study the velocity autocorrelation function (VACF) of a driven granular fluid in the stationary state in 3 dimensions with the help of event driven molecular dynamic simulations. As the critical volume fraction of the glass transition in the corresponding elastic fluid is approached, we observe pronounced cage effects in the VACF as well as a strong decrease of the diffusion coefficient, depending on the strength of the inelasticity. At moderate densities the VACF is shown to decay algebraically in time like $t^{-3/2}$ if momentum is conserved locally, and like t^{-1} if momentum is not conserved by the driving. A simple scaling argument supports the observed long-time tails.

DY 18.5 Wed 17:15 HÜL 386

Measurement of fluctuation-dissipation temperature in a driven dense granular suspension. — •Sonia May[1], Alexander Buck[2], Harry Swinney[2], and Matthias Schröter[1] — [1]Max-Plank-Institut für Dynamik und Selbstorganisation, Göttingen, Germany — [2]Center for Nonlinear Dynamics, UT Austin

We use a water-fluidised bed to drive a dense suspension of glass spheres. We can control the kinetic energy of the suspended grains by changing the flow rate and viscosity of the liquid used to fluidise them. A sphere covered with grains and connected to a torsional pendulum is immersed in the suspension, with which we measure the fluctuation-dissipation temperature of the suspension at very low driving rates. The slow driving enables us to measure energy scales even below the limit at which fluidisation becomes macroscopically visible. Here, we observe a divergence of a damping term, the granular equivalent of viscosity. This we attribute to a granular equivalent of the glass transition.

15 min. break.

DY 18.6 Wed 17:45 HÜL 386

The Velocity Autocorrelation Function of a Driven Granular Fluid — •W. Till Kranz, Andrea Fiege, and Annette Zippelius — Institute for Theoretical Physics, University of Göttingen and MPI for Dynamic and Self Organization, Göttingen, Germany

We extend the equilibrium mode coupling theory (MCT) of molecular fluids [1] to the steady state of a driven granular fluid. This allows us to derive an analytic expression for the velocity autocorrelation function $\psi(t) \sim \langle \mathbf{v}_s(0)\mathbf{v}_s(t)\rangle$. We will briefly outline the key assumptions that form the basis of our derivation. Subsequently we will discuss how the rich phenomenology already present in the equilibrium hard sphere gas [2] carries over to the non-equilibrium case of a granular fluid. In particular we will focus on long-time tails, backscattering and the suppression of diffusion at high densities. In order to asses the range of validity of the theoretical predictions we compare it to extensive numerical data that has recently become available [3].
[1] W. Götze, in *Liquids, Freezing and Glass Transition* (North Holland, 1991)
[2] B. J. Alder, E. Wainwright, Phys. Rev. Lett. **18**, 988 (1967)
[3] A. Fiege, T. Aspelmeier, A. Zippelius, arXiv:0809.4432 to appear in PRL

DY 18.7 Wed 18:00 HÜL 386

Granular Robots — •Zeina Khan[1], Audrey Steinberger[1], Ralf Seemann[1,2], and Stephan Herminghaus[1] — [1]MPI for Dynamics and Self-Organization, Bunsenstr. 10, D-37073 Goettingen, Germany — [2]Experimental Physics, Saarland University, D-66041 Saarbruecken, Germany

We have observed that when a bidisperse 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 travel horizontally along the axis of vibration. We report on various 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 detailed analysis of the interplay between rotation and sliding in the beads' motion.

DY 18.8 Wed 18:15 HÜL 386

Modelling particulate self-healing materials and application to uni-axial compression — •Olaf Herbst[1,2], Akke Suiker[1], and Stefan Luding[2] — [1]Aerospace Engineering, TU Delft, Kluyverweg 1, 2629 HS Delft, The Netherlands — [2]Multi Scale Mechanics, TS, CTW, UTwente, P.O. Box 217, 7500 AE Enschede, The Netherlands

Using an advanced history dependent contact model for DEM simulations, including elasto-plasticity, viscosity, adhesion, and friction, pressure-sintered tablets are formed from primary particles. These tablets are subjected to uni-axial compression until and beyond failure displaying peak strength. For fast and slow deformation we observe ductile-like and brittle softening, respectively.

We propose a model for local self-healing that allows damage to heal during the loading process such that the material strength of the sample increases and failure/softening is delayed to larger strain. Local healing is achieved by increasing the (attractive) contact adhesion forces for those particles involved in a potentially breaking contact.

We examine the dependence of the strength of the material on (a) the damage detection sensitivity, (b) the damage detection rate, and (c) the (increased) adhesion between healed contacts. The material strength is enhanced, i.e. the material fails at larger strains and reaches larger maximal stress values, when any of the parameters (a) – (c) is increased.

DY 18.9 Wed 18:30 HÜL 386

Wet Discs Running Down an Inclined Plane — •Seyed Habibollah Ebrahimnazhad Rahbari, Martin Brinkmann, Juergen Vollmer, and Stephan Herminghaus — Dept. Dynamics of Complex Fluids, MPI for Dynamics and Self-Organization, D-37073 Göttingen, Germany

We present results of MD-type simulations of wet discs running down an inclined plane. In our model, particles interact via a repulsive force, when they overlap, and via a hysteretic attractive force caused by liquid bridges. A liquid bridge forms when two adjacent wet discs touch each other, and entails to an attractive hysteretic force $F_{lb}(x)$ due to the surface tension of the liquid. That capillary bridge ruptures when the distance between two grains exceeds a critical separation S_c and dissipates energy. We use a minimal capillary model in which F_{lb} is assumed to be constant as the liquid bridge is stretched. The dissipation in our model is only due to the rupture events of the liquid bridges.

The systems are set up by sedimentation of the discs, and immobilization of discs touching the bottom wall. Subsequently, a tilted force is applied. We find a simple scaling expression for the fluidization transition as a function of the gravitational acceleration g, the inclination angle θ, and the rupture separation S_c. For most parameter values beyond the transition, the system settles down into to a stationary homogeneous fluidized state. However, there are also regimes where it becomes bistable or shows a thermal runaway.