DY 13: Granular Matter/ Contact Dynamics II

Time: Wednesday 9:30–12:30 Location: H47

Invited Talk DY 13.1 Wed 9:30 H47

Glass transition in driven granular fluids — •Annette Zippelius[1], Till Kranz[1], and Matthias Sperl[2] — [1]Institut für Theoretische Physik, Universität Göttingen, Friedrich-Hund Platz 1, 37077 Göttingen — [2]Institut für Materialphysik im Weltraum, Deutsches Zentrum für Luft- und Raumfahrt, 51170 Köln

We study a homogeneously driven granular fluid at high volume fractions. A mode-coupling theory is derived for the stationary, non-equilibrium state, which is reached, when dissipation due to inelastic collisions is balanced by the driving, which is applied to the bulk of the fluid. As the density is increased beyond a critical value n_c we observe a glass transition indicated by a time persistent part of the van Hove correlation function. The transition is qualitatively similar to the corresponding one in the elastic fluid with however different values for the critical density as well as the exponents which characterize the slow dynamics preceding structural arrest. We also present results of event driven simulations, which reveal a plateau in the mean square displacement and a strong decrease of the diffusion constant as the glass transition is approached.

DY 13.2 Wed 10:00 H47

Glass-Transition for Dissipative Systems under Driving — •Till Kranz[1,2], Matthias Sperl[1,3], and Annette Zippelius[1,2] — [1]Institut für Theoretische Physik, Universität Göttingen — [2]MPI für Dynamik und Selbstorganisation, Göttingen — [3]Institut für Materialphysik im Weltraum, DLR Köln

In order to reach a steady state, granular (dissipative) systems need an external driving. One of the many possible methods is to fluidise the system by a fluctuating driving force. We extend the equilibrium mode coupling theory (MCT) of molecular fluids [1] to the steady state of such a randomly driven granular fluid. This allows us to calculate the coherent scattering function $\Phi(q,t) = \langle \rho_q(0)|\rho_q(t)\rangle$. We observe a mode coupling glass transition for all dissipation strengths characterized by a constant coefficient of normal restitution ϵ. The critical density φ_c increases with increasing dissipation. Close to the critical density we predict a two step relaxation of dynamical correlation functions. Both the plateau height f_q as well as the critical exponents differ from those found for equilibrium glass-formers.

[1] W. Götze, *Complex Dynamics of Glass-Forming Liquids: A Mode-Coupling Theory*, (Oxford University Press, 2009)

DY 13.3 Wed 10:15 H47

Driven two-dimensional granular fluids exhibit precursors to glass transition — •Iraj Gholami, Andrea Fiege, and Annette Zippelius — Institute of Theoretical Physics, University of Göttingen, Germany

We employ event-driven simulations of two-dimensional granular systems with constant coefficient of restitution to investigate its long-time behavior for different volume fractions up to 0.82. The driving is chosen such that momentum is conserved on local scales and a stationary state is reached, allowing us to calculate time dependent correlation functions and the mean square displacement. In order to avoid crystallization we use bi-disperse systems. The mean square displacement shows a pronounced plateau when increasing the volume fraction while the velocity autocorrelation function exhibits long-time tails $\propto t^{-1}$.

DY 13.4 Wed 10:30 H47

Networks of Wet Elastic Cylinders — •Ohle Claussen, Martin Brinkmann, and Stephan Herminghaus — MPI for Dynamics and Self-Organization Göttingen, Germany

Liquid bridges held between two cylindrical surfaces exert not only capillary forces onto the wetted bodies, they also induce torques. Depending on the tilt angle and separation of the surfaces, and controlled by the liquid volume or pressure a variety of liquid equilibrium shapes can be observed. Some of these liquid structures exert aligning torques which have an impact on the structure and mechanical behaviour of disordered networks of cylindrical fibres. We present numerical studies of the liquid morphologies arising in systems of macroscopic cylinders, as well as simulations of random elastic fibre networks based on an effective sliding bond model to account for the effect of capillary bridges. The growth of pores in such a network is investigated, and an alternative lattice gas model is presented to motivate the applicability of the effective model.

DY 13.5 Wed 10:45 H47

Fluidization of wet granulates under shear — Seyed H. Ebrahimnazhad Rahbari, Juergen Vollmer, Stephan Herminghaus, and •Martin Brinkmann — MPI for Dynamics and Self-Organization, 37073 Göttingen

It is a common experience that small amounts of a wetting liquid like water render sand a stiff and moldable material. The cohesive forces between the sand grains are caused by capillary bridges at the points of contact. Due to the finite strength of these bridges wet sand undergoes a transition from a solid to a fluidized state under an externally applied shear force. The transition between these two dynamic states is studied in a MD-type simulation of a two-dimensional assembly of bidisperse frictionless disks under the action of a cosine force profile. In addition to soft core repulsion the disks interact through a hysteretic and short ranged attractive force modeling the effect of the capillary bridges. In this model the transition between the fluidized and the solid state is discontinuous and hysteretic. As the system size is increased the opening of the hysteresis loop becomes smaller. The parameter dependence of the critical force for solidification is modeled by combining theoretical predictions based on free volume arguments with a detailed numerical exploration of the transition.

DY 13.6 Wed 11:00 H47

Acceleration, Clustering and Superlong Transients in a Billiard Model for Wet Granular Matter — Franziska Glassmeier, Diego Fregolente, Martin Brinkmann, and •Jürgen Vollmer — MPI for Dynamics and Self-Organization, Bunsenstr. 10, 37073 Göttingen, Germany

We generalize the collisions rules of the Sinai billiard to mimic collisions of two wet disks. The dissipative interaction of the disks leads to cooling and eventually to clustering. To work against this energy loss we shear the system by applying Lees-Edwards boundary conditions.

For sufficiently high shear rates the energy input due to shearing overcompensates the dissipative interaction such that the ensemble average of the particle energy $\langle E\rangle$ increases linearly. Energies are distributed according to an exponential function that scales with $\langle E\rangle$. This has unexpected consequences: Due to the very large energy fluctuations the system has a leak for all shear rates. Consequently, the disks may cluster even when started from very high energies.

Suprisingly, we observe an algebraic distribution of lifetimes. It is due to the non-compact phase space of the accelerating system. A relation of this phenomenon to Fermi acceleration in time-dependent billiards, and generalizations to more particles are discussed in the end.

DY 13.7 Wed 11:15 H47

Structure Factors of Driven Granular Fluids underlying Stokes Drag — •Andrea Fiege[1,2], Timo Aspelmeier[1,2], and Annette Zippelius[1,2] — [1]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany — [2]Institute for Theoretical Physics, University of Göttingen, Germany

We study a monodisperse system of hard spheres which is subject to two dissipative mechanisms, the inelasticity of collisions and the loss of energy due to a drag force caused by a surrounding fluid, such that the Langevin equation of the system becomes $\frac{\mathrm{d}}{\mathrm{d}t}\mathbf{v}_i = -\gamma_S \mathbf{v}_i + \frac{\mathbf{F}_i}{m_i} + \boldsymbol{\xi}_i$, where $\mathbf{F}_i$ denotes the systematic force on the particle due to collisions and the energy source $\boldsymbol{\xi}_i$ provides a stationary state by adding random momentum to each particle. The drag force suppresses the random walk of the center of mass of the system caused by the random kicks. We introduce an event-driven algorithm that is capable of including a drag force and investigate the structure factors of the system.

DY 13.8 Wed 11:30 H47

Shear Band Patterns in Biaxial Shear Tests of Granular Materials — •Thomas Stegmann, Janos Török, Lothar Brendel, and Dietrich E. Wolf — Faculty of Physics and CeNIDE, University of Duisburg-Essen, 47048 Duisburg, Germany

The theory of minimal dissipation identifies the position of the optimal shear band in granular materials by minimizing the dissipation rate. The strength of the theory comes forward in non-trivial scenarios as modified Couette cell [1] and granular refraction [2]. In true biaxial

shear tests with frictionless walls the theory predicts ever changing shear band configurations that are optimal only for a given sample aspect ratio, with a constant angle equal to the Mohr-Coulomb angle and a constant macroscopic stress ratio [3]. A new quantity was introduced to identify shear bands in simulations which shows only partial agreement with the theory due to fluctuations and high degeneration of the optimum. This degeneracy can be decreased by introducing wall friction since there is only one shear band configuration which does not have any tangential velocity difference with the walls. It is expected that the stress ratio will be minimal at the optimal aspect ratio for this specific configuration. Apart from this point we expect to find shear band angles different from the Mohr-Coulomb angle. All theoretical results match very well with contact dynamics simulations.

[1] T. Unger et al., Phys. Rev. Lett. **92**, 214301 (2004).

[2] T. Unger, Phys. Rev. Lett. **97**, 018301 (2007).

[3] J. Török et. al. in Powders and Grains 2009, Melville NY, p. 417

DY 13.9 Wed 11:45 H47

Yield stress and shear modulus in frictional granular packing — •Jean-Francois Metayer[1], Donald Trey Suntrup III[2], Harry Swinney[2], Charles Radin[3], and Matthias Schroeter[1] — [1]MPI for Dynamics and Selforganization, Göttingen, Germany — [2]Center for Nonlinear Dynamics, University of Texas, Austin, USA — [3]Departments of Mathematics, University of Texas, Austin, USA

A granular system is able to behave like a solid (a sand pile for example) or like a liquid depending on the shear stress imposed on the material. This study is focused on the phase transition between those two states and its goal is to obtain an experimental phase diagram of a granular media in three dimensions.

The yield stress of our granular media is obtained by measuring the force, F, needed to pull-up a paddled immersed in a granular bed as a function of its packing fraction and the depth of immersion. Fluctuations of F give us access to a measurement of the shear modulus, G, as a function of the same parameters. Results we present here clearly evidence that the value of the shear stress, needed to unjam our granular media, and its shear modulus are strongly related to the packing fraction: for low packing fraction ($<\approx 0.59$) F and G are constant with ϕ whereas their value are highly dependant on ϕ for higher packing fraction.

DY 13.10 Wed 12:00 H47

Local Anisotropy in jammed spherical bead packs — •Gerd E. Schröder-Turk[1], Walter Mickel[1], Mohammad Saadatfar[2], Tim Senden[2], Matthias Schröter[3], Gary Delaney[4], Klaus Mecke[1], and Tomaso Aste[5] — [1]Theoretische Physik, Friedrich-Alexander Universität Erlangen-Nürnberg, Staudtstr. 7B, 91058 Erlangen — [2]Applied Maths, School of Physics, The Australian National University, 0200 ACT, Canberra, Australia — [3]Center for Nonlinear Dynamics and Dept. of Physics, University of Texas, Austin, TX 78712, USA — [4]CSIRO Mathematical and Information Sciences, Private Bag 33, Clayton South, VIC, 3168, Australia — [5]School of Physical Sciences, University of Kent, Canterbury, Kent, CT2 7NH, UK

We report significant structural anisotropy in disordered mono-disperse bead packs manifest in the shape of the Voronoi cells. This result is based on an analysis of several experimental and simulated packings. The anisotropy of the Voronoi cell shape is characterized by a robust method based on tensorial Minkowski functionals. The degree of anisotropy is found to decrease with increasing packing fraction ϕ for $0.55 \leq \phi \leq 0.64$ and to be insensitive to packing details and protocols. We observe a distinct change in the trend of the anisotropy when ϕ becomes larger than 0.64 and also when the system passes from unjammed to jammed configurations. The anisotropy of the Voronoi cell shape is a packing effect without significant alignment with the vertical or horizontal axes.

DY 13.11 Wed 12:15 H47

Unjamming of granular packings due to local perturbations — •reza shaebani[1], tamas unger[2], dietrich wolf[1], and janos kertesz[2] — [1]Computational and Statistical Physics Group, Department of Theoretical Physics, University of Duisburg-Essen, 47047 Duisburg, Germany — [2]Department of Theoretical Physics, Budapest University of Technology and Economics, H-1111 Budapest, Hungary

One of the most exciting research challenges for granular media is to provide better understanding of the onset of yielding. When the external load on a static assembly of grains is changed at a certain point the load may become incompatible with the inner structure of the packing and the solid state loses its stability. How exactly this happens on the grain scale and what are the key features of the transition between statics and flow are intriguing and unresolved problems.

In this study, the unjamming response of dense disordered granular media is investigated based on CD and MD simulations. We break the static structure of the packings by small local deformations and induce motion of particles. We determine the critical force of the local perturbation that is needed to break the mechanical equilibrium and examine the generated displacement field. We find that displacements decay as a power law of the distance from the perturbation point. We show that the decay exponent and the critical force are nonmonotonic and have a sharp maximum at the friction coefficient 0.1. We find that the mechanical response properties are closely related to the problem of force-indeterminacy.