DF 22: Slow Dynamics in Glasses and Granular Matter I (Joint Focus Session with DY and CPP)

The transition into an amorphous solid state is typically accompanied by the observation of slow dynamics. The understanding of such transitions from first principles has seen progress in many of its aspects recently, including nonlinear response, residual stresses, and non-affine deformations. The Focus Session provides an overview of common phenomena and of general concepts in the physical picture of disordered materials. (Organizers M. Sperl and A. Zippelius)

Time: Thursday 9:30–12:30 Location: HÜL 186

Invited Talk DF 22.1 Thu 9:30 HÜL 186
The memory of sand — •Matthieu Wyart — New York University

Complex systems are characterized by an abundance of meta-stable states. To describe such systems statistically, one must understand how states are sampled, a difficult task in general when thermal equilibrium does not apply. This problem arises in various fields of science, and here I will focus on a simple example, sand. Sand can flow until one jammed configuration (among the exponentially many possible ones) is reached. I will argue that these dynamically-accessible configurations are atypical, implying that in its solid phase sand "remembers" that it was flowing just before it jammed. As a consequence, it is stable, but barely so. I will argue that this marginal stability answers long-standing questions both on the solids and liquid phase of granular materials, and will discuss tentatively the applicability of this idea to other systems.

Invited Talk DF 22.2 Thu 10:00 HÜL 186
Complex rheology at the jamming transition: shear thickening, shear thinning, shear banding — •Claus Heussinger — Institut für theoretische Physik, Universität Göttingen

The jamming paradigm aims at providing a unified view for the elastic and rheological properties of materials as different as foams, emulsions, suspensions or granular media. The usefulness of such a unifying concept hinges on the presence or absence of phenomena that are in some sense *universal*.

In this contribution, we discuss how certain features in the particle interactions affect the rheological properties of the material. First, we discuss the effect of frictional forces, and show how the jamming phase diagram has to be modified as compared to the frictionless scenario [1,2]. Essential findings are a discontinuous and hysteretic jamming transition, as well as a shear thickening regime where frictionless particles are generically shear thinning.

Secondly, we investigate the role of attractive interactions between the particles [3]. For weakly attractive systems a fragile solid develops which displays self-organization towards a minimal (isostatic) connectivity. Moreover, the measured flow curves have unstable regimes, which lead to persistent shearbanding. These features are rationalized by establishing a link between rheology and inter-particle connectivity, which also provides a minimal theoretical model to describe the flow curves.

[1] CH, PRE (2013). [2] M. Grob. CH, A. Zippelius, arXiv (2013). [3] E. Irani, P. Chaudhuri, CH, arXiv (2013).

DF 22.3 Thu 10:30 HÜL 186
Stress-birefringence information in three-dimensional binary granular packings — •Peidong Yu, Stefan Frank-Richter, and Matthias Sperl — Institut für Material Physik im Weltraum, Köln, Deutschland

We report our newly developed 3D stress-birefringence technique and its application in a binary static packing. We show how we precisely determine the stress state of one single spherical particle from its stress-birefringent response to external contacts. Such particles of two different sizes are used in a dense packing with different packing fractions. Based on the knowledge of one-particle calibration, we are able to define a transition point from the integrated stress-birefringent signal of the whole packing under changing packing fraction. Variations of these transition points with different size ratio and specie number ratio of the two particle species are measured and discussed.

DF 22.4 Thu 10:45 HÜL 186
Jamming of Frictional Particles: a First Order Phase Transition — •Matthias Grob[1], Claus Heussinger[2], and Annette Zippelius[1,2] — [1]Max-Planck-Institut für Dynamik und Selbstorganisation, Göttingen, Deutschland — [2]Institut für Theoretische Physik, Universität Göttingen, Göttingen, Deutschland

With numerical simulations, we produce flow curves for dense frictional granular media with features different from the frictionless analog. When the strain rate is controlled and increased, a smooth transition from inertial to plastic flow is observed below a critical volume fraction. Above this packing fraction, the transition becomes discontinuous as a hallmark of friction. Upon an increase of packing fraction, the flow curves show hysteretic behaviour, the emergence of a yield stress and the divergence of the shear viscosity - each at a different packing fraction. All the reported behaviour is reproduced with a simple model for a non-equilibrium first order phase transition. An inherent feature of dense frictional granular rheology is that the transition from flowing to jammed states is reentrant with transient jam-and-flow states in between which are, within the models' framework, metastable flow states.

15 min. break

DF 22.5 Thu 11:15 HÜL 186
Vibrational Masking of Critical Decay in the Early beta-Relaxation Regime of Incoherent Intermediate Scattering Functions in Simulated Glass Forming Ni0.5Zr0.5 — •Helmar Teichler — Institut f. Materialphysik, Univ. Göttingen

Results are presented concerning the origin of discrepancy between mode coupling theory (MCT) prediction for critical decay in the early beta-regime and molecular dynamics (MD) simulation data. The discrepancy is known since long in the literature and is heuristically ascribed to effects of atomic vibrations not fully taken into account in MCT. A proper theoretical treatment is missing so far. Here I present a formally exact framework for analyzing the MD data, which allows deducing the origin of the discrepancy and its quantitative description, and I apply it to MD simulated glass forming Ni0.5Zr0.5. The approach relates incoherent intermediate scattering functions (ISFs) from atomic trajectories, which show the discrepancy, to those from inherent structure (IS), which are in agreement with MCT. Cumulant expansion of the ISFs demonstrates that the discrepancy reflects the vibrational density of states, with minor effect of the Boson peak. The results for Ni0.5Zr0.5 rely on the fact that there are only weak correlations between atomic vibrations and IS relaxation displacements in the beta-regime, and that the essential part of the vibrational displacements distribution acts Gaussian-like.

DF 22.6 Thu 11:30 HÜL 186
Glass Transition of Yukawa Systems: Crossover from Hard Sphere to Soft Sphere Limits — •Anoosheh Yazdi[1], Alexei Ivlev[2], Sergei Khrapak[2], Adam Wysocki[3], Hartmut Löwen[4], and Matthias Sperl[1] — [1]Institut für Materialphysik im Weltraum, Deutsches Zentrum fuer Luft- und Raumfahrt, 51147 Köln, Germany — [2]Max-Planck-Institut für extraterrestrische Physik, 85741 Garching, Germany — [3]Institute for Advanced Simulation and Institute of Complex Systems, Forschungszentrum Jülich, 52425 Jülich, Germany — [4]Institut für Theoretische Physik II, Heinrich-Heine-Universität Düsseldorf, 85741 Düsseldorf, Germany

The mode-coupling theory for ideal glass transitions (MCT) is applied to the single and double Yukawa potential systems. Glass transition curves are obtained in the full range of two control parameters: the screening parameter κ, which is the inverse screening length, and the interparticle potential strength Γ. With increasing κ along the transition, glass form factors and effective packing fractions undergo a crossover from the one-component plasma (OCP) limit, which resembles a very soft sphere system, to a hard sphere system (HSS). The entire transition diagram can be described by analytical functions. Suprisingly and different from those of other potentials, glass transition curves are found to be shifted but otherwise identical to the melting curves in the control parameter plane.

DF 22.7 Thu 11:45 HÜL 186

rheology near jamming-the influence of lubrication forces —

•moumita maiti and Claus Heussinger — Georg-August University of Goettingen, Goettingen, Germany

The talk discusses the role of different dissipation forces on the rheological properties of highly dense non-Brownian suspensions. The focus is on the random close packing limit (”jamming”) where particle motion is limited due to steric volume exclusion. We define a simplified lubrication force where we change the dissipation mechanisms by tuning the range of the interaction. Two densities are considered, one is near jamming the other further away. For both densities, a crossover is seen from 'inertia' dominated flow to viscous flow by changing the lubrication range. Interestingly, we observe that velocity fluctuations are independent of the different dissipation mechanisms (”universal”)near jamming. Away from jamming this universality is lost and an unexpected non-monotonic dependence is seen. We present an understanding of our findings in terms of geometric constraints of random-close packing and a decoupling of dissipative forces and particle trajectories.

DF 22.8 Thu 12:00 HÜL 186

Lattice Boltzmann Simulations for Glass-Forming Liquids —

•Simon Papenkort[1,2] and Thomas Voigtmann[1,2] — [1]Institut für Materialphysik im Weltraum, Deutsches Zentrum für Luft- und Raumfahrt, Köln, Germany — [2]Zukunftskolleg und Fachbereich Physik, Universität Konstanz, Germany

In continuum mechanics, the Navier-Stokes (NS) equation is used to study fluid flows. The Lattice Boltzmann (LB) model is an efficient method to find solutions of the NS equation of Newtonian liquids even for complex flow geometries.

Complex fluids, such as glass formers, colloidal suspensions, or granular media, display a wide range of non-Newtonian flow effects, determined by the interplay between slow structural dynamics on the microscopic scale, and the mesoscopic flow field. Prominent examples are shear thinning and yield stresses, leading to plug flow in channels.

Starting from first principles, mode coupling theory of the glass transition is able to provide constitutive equations that describe the history effects determining the flow of glass-forming fluids. We present results from a new LB scheme that allows to include memory-integral effects in fluid-mechanics simulations.

DF 22.9 Thu 12:15 HÜL 186

Slow convection in densely packed granular mixtures —

•Frank Rietz and Ralf Stannarius — University of Magdeburg, Institute of Experimental Physics, Department of Nonlinear Phenomena

Handling of granulate in partly filled rotating containers is a common situation in industrial processes. Contrary to ensembles of loosely packed grains, the container can be filled so dense that fluidization is limited to a shallow surface layer. Then, the deeper layers are in a locked state, only creeping motions on longer time scales are possible.

We study such a situation in a flat rotating container of aspect ratio 1 that is almost completely filled with a bidisperse mixture. Irrespective of the limited mobility of the grains we observe nonuniform segregation patterns accompanied by slow convective motion. Many features of the convection flow amplitude, like regular oscillatory modulations of the convection velocity, cessations and spontaneous reversals of the circulation are comparable to convection in ordinary liquids at high Rayleigh numbers, in geometries with aspect ratio 1.

[1] F. Rietz & R. Stannarius, Phys. Rev. Lett. 108, 118001 (2012).