DF 28: Slow Dynamics in Glasses and Granular Matter II (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: Friday 9:30–12:15 Location: HÜL 186

Invited Talk DF 28.1 Fri 9:30 HÜL 186
Critical Rheology of Weakly Vibrated Granular Media — •Martin Van Hecke — Huygens-Kamerlingh Onnes Lab, Leiden University

We experimentally probe the rheology of weakly vibrated granular media, and show that much of it is controlled by a nontrivial 2nd order-like critical point that occurs at finite stress and vibration strength. Close to this critical points, fluctuations become strong, correlation times diverge, and the flow curves exhibit scaling. For smaller vibrations, a 1st order transition emerges which separates a glassy phase from a rapidly flowing phase.

DF 28.2 Fri 10:00 HÜL 186
THz scattering from granular media — •Philip Born[1], Heinz-Wilhelm Hübers[2], Nick Rothbart[2], and Matthias Sperl[1] — [1]DLR Institute of Materials Physics in Space, Cologne, Germany — [2]DLR Institute of Planetary Research, Berlin, Germany

The structure and dynamics of driven dissipative granular media seems to be captured well by simulations. However, the results still evade experimental verification. The dynamics in colloidal suspension in contrast can be investigated comprehensively using light scattering techniques. The particle sizes in common experimental realisations of dense driven granular media, usually with particle sizes above 0.1mm, prevent application of imaging methods and established light scattering methods. Here we present approaches to the structure and dynamics of granular media using Thz radiation based light scattering. The matched wavelength ensures high sensitivity to geometric features of granular particle packings and paves the way for in-situ investigations of driven granular media.

DF 28.3 Fri 10:15 HÜL 186
Correlations and response in sheared hard sphere glasses — •Suvendu Mandal[1], Dierk Raabe[1], and Fathollah Varnik[2] — [1]Max-Planck Institut für Eisenforschung, Max-Planck Str. 1, 40237 Düsseldorf, Germany — [2]Interdisciplinary Centre for Advanced Materials Simulation (ICAMS), Ruhr University Bochum, Universitätsstr. 150, 44801 Bochum, Germany

Via event-driven molecular dynamics simulations, we study the packing-fraction and shear-rate dependence of single-particle fluctuations and dynamic correlations in hard-sphere glasses under shear [1]. At packing fractions above the glass transition, correlations increase as shear rate decreases: the exponential tail in the distribution of single-particle jumps broadens and dynamic four-point correlations increase. Interestingly, however, upon decreasing the packing fraction, a broadening of the exponential tail is also observed, while dynamic heterogeneity is shown to decrease. An explanation for this behavior is proposed in terms of a competition between shear and thermal fluctuations. We further address the issue of anisotropy of the dynamic correlations [2,3].

[1] Suvendu Mandal, Markus Gross, Dierk Raabe, and Fathollah Varnik, PRL. 108, 098301 (2012). [2] Suvendu Mandal, Vijaykumar Chikkadi, Bernard Nienhuis, Dierk Raabe, Peter Schall, and Fathollah Varnik, PRE. 88, 022129 (2013). [3] Vijaykumar Chikkadi, Suvendu Mandal, Bernard Nienhuis, Dierk Raabe, Peter Schall, and Fathollah Varnik, EPL. 100, 56001 (2012).

DF 28.4 Fri 10:30 HÜL 186
Granular matter composed of shape-anisotropic grains under shear — Ralf Stannarius[1], Sandra Wegner[1], Tamás Börzsönyi[2], and •Balázs Szabó[2] — [1]Inst. of Experimental Physics, University of Magdeburg, Germany, — [2]Institute for Solid State Physics and Optics, HAS, Budapest, Hungary

This contribution establishes a link between two different soft matter systems that can develop orientational order, liquid crystals and granular matter. We present shear experiments with prolate (ellipsoids, cylinders) and oblate (lentils) particles and discuss the observed order and alignment. Positions and orientations of the individual grains in the bulk are resolved by X-ray tomography. Shear experiments show that many observations are qualitatively and even quantitatively comparable to the behavior of the well-understood molecular liquid crystal mesophases, even though the types of interactions are completely different. We establish a quantitative relation between shear alignment and aspect ratio and investigate the interrelations to shear dilatancy and macroscopic friction properties. Long-range effects like particle rearrangements by creeping motion far from the shear band are detected.

15 min. break

Invited Talk DF 28.5 Fri 11:00 HÜL 186
A Granular Ratchet: Spontaneous Symmetry Breaking and Fluctuation Theorems in a Granular Gas — •Devaraj van der Meer[1], Sylvain Joubaud[2], Peter Eshuis[1], Ko van der Weele[3], and Detlef Lohse[1] — [1]University of Twente, The Netherlands — [2]ENS and University of Lyon, France — [3]University of Patras, Greece

We construct a ratchet of the Smoluchowski-Feynman type, consisting of four vanes that are allowed to rotate freely in a vibrofluidized granular gas. The necessary out-of-equilibrium environment is provided by the inelastically colliding grains, and the equally crucial symmetry breaking by applying a soft coating to one side of each vane. The onset of the ratchet effect occurs at a critical shaking strength via a smooth, continuous phase transition. For very strong shaking the vanes interact actively with the gas and a convection roll develops, sustaining the rotation of the vanes. From the experimental results we show that a steady state fluctuation relation holds for the work injected to the system, and that its entropy production satisfies a detailed fluctuation theorem. Surprisingly, we find that the above relations are satisfied to some extent even when a convection roll has developed and there exists a strong coupling between the motion of the vanes and the granular gas.

DF 28.6 Fri 11:30 HÜL 186
Granular Microrheology in the Large Force Regime — •Ting Wang[1], Matthias Grob[2], Annette Zippelius[2], and Matthias Sperl[1] — [1]Institut für Materialphysik im Weltraum, Deutsches Zentrum für Luft- und Raumfahrt (DLR), 51170 Köln — [2]Georg-August-Universität Göttingen, Institut für Theoretische Physik, Friedrich-Hund-Platz 1, 37077 Göttingen

When pulling a particle in a driven granular system with constant force F, the probe particle may approach a steady velocity v. In the large force regime, it was found in our recent simulation that the effective friction coefficient F/v increases with increasing F, being proportional to the square-root of F, while some earlier Brownian dynamics simulations and theories predicted constant friction coefficient. Here, we study the behavior in granular microrheology by a schematic model of mode-coupling theory (MCT) and a simple kinetic theory. Our schematic model qualitatively reproduces the increase of friction tendency but fails to exhibit the square-root law. In the low density limit, the square-root law can be derived from the kinetic theory, based on which, we clarify the discrepancy of the large force behaviors in driven granular systems and Brownian ones.

DF 28.7 Fri 11:45 HÜL 186
Integration Through Transients Approach to the Rheology of a Sheared Granular Fluid — •Till Kranz[1], Fabian Frahsa[2], Matthias Fuchs[2], Matthias Sperl[3], and Annette Zippelius[1] — [1]Institut für Theoretische Physik, Universität Göttingen — [2]Fachbereich Physik, Universität Konstanz — [3]Institut für Materialphysik im Weltraum, DLR Köln

We generalize the Integration through Transients (ITT) formalism to the non-equilibrium stationary state of randomly driven inelastic hard spheres. ITT was first developed for Brownian suspensions [1] and recently extended to thermostated Newtonian systems [2]. As a result we get generalized Green-Kubo-relations and an equation of motion for the transient density correlator.

Since the seminal work of Bagnold [3] it has been recognized that dissipative hard spheres (i.e. granular particles) have an unusual rheology. In particular, the shear stress σ varies with the square of the shear rate $\dot{\gamma}$, i.e., Bagnold scaling, $\sigma = \eta\dot{\gamma}^2$, holds. We will discuss the response to shear and the dependence on the degree of inelasticity and packing fraction. This includes the transient density correlator and the prefactor, η, of the Bagnold scaling relation. We will comment on the relation to the elastic [1,2] and the unsheared case [4], clarifying how Bagnold scaling emerges.

[1] M. Fuchs, M. E. Cates, J. Rheol. 53, 957 (2009)
[2] K. Suzuki, H. Hayakawa, Phys. Rev. E 87, 012304 (2013)
[3] R. A. Bagnold, Proc. R. Soc. Lond. A 225, 49 (1954)
[4] W. T. Kranz, *et al.*, Phys. Rev. E 87, 022207 (2013)

DF 28.8 Fri 12:00 HÜL 186

Nonlinear rheology of colloidal systems with attractive interactions: A mode-coupling theory analysis — •Madhu Priya and Thomas Voigtmann — Institut für Materialphysik im Weltraum, Deutsches Zentrum für Luft- und Raumfahrt (DLR), Köln, Germany

Hard spheres with a short-ranged attraction are a model system for colloid-polymer mixtures. These systems display two separate glasses, attractive and repulsive, connected with glass-glass transitions and higher-order glass-transition singularities. We study the nonlinear rheology of the square-well system in the vicinity of the glass-glass transition, using mode-coupling theory (MCT) in an isotropic-shear approximation. The yield strength and yield strains are studied, depending on packing fraction, attraction range, and strength. The findings of the model are compared with the observations made by recent experiments and computer simulation studies for colloid-polymer systems.