DY 19: Franco-German Session on Granular Matter I

Granular media exhibit rich collective behavior arising from simple interactions such as friction, collisions, elasticity, and confinement. This session brings together experimental, numerical, and theoretical studies addressing key transitions in granular systems, including jamming, viscous-to-inertial regimes, clustering, gas cooling, and impact dynamics, highlighting the links between microscopic mechanisms and macroscopic responses.

Organized by Baptiste Darbois Texier (Paris) and Franco Antonio Tapia Uribe (Dresden)

Time: Tuesday 9:30–12:45 Location: HÜL/S186

Invited Talk DY 19.1 Tue 9:30 HÜL/S186

Mechanics of entangled fibers — •Olivier Pouliquen[1], Aubin Archambault[1], Ignacio Andrade[2], Jerome Crassous[3], Henri Lhuissier[1], and Joël Marthelot[1] — [1]IUSTI, CNRS-Aix Marseille University, Marseille, France — [2]Departamento de Física, Universidad de Chile, Santiago, Chile — [3]CNRS - ESPCI Université PSL/Sorbonne Université/Université de Paris, paris, France

When long, flexible fibers are densely packed, they form cohesive structures, such as those found in bird*s nests, cotton balls, or fibrous insulation materials. These peculiar granular assemblies exhibit complex mechanical behaviors: they can be compacted and sustain tensile stress, despite the absence of adhesive bonds. Through experiments on model materials and discrete-element simulations, we investigate the interplay between elasticity and friction that governs the mechanics of entangled, non-bonded fiber networks.

DY 19.2 Tue 10:00 HÜL/S186

Rheology of suspensions of non-Brownian spheres across the jamming and viscous-to-inertial transition — •Franco Tapia[1,2], Olivier Pouliquen[2], Chong-Wei Hong[2], Pascale Aussillous[2], and Elisabeth Guazzelli[3] — [1]Institute of Urban and Industrial Water Management, TU Dresden, Dresden, Germany — [2]Aix-Marseille Université, CNRS, IUSTI, Marseille, France — [3]Université Paris Cité, CNRS, Matiére et Systèmes Complexes (MSC) UMR 7057, Paris, France

We study the rheology of suspensions of non-Brownian hard and soft particles across the jamming transition and within both viscous and inertial flow regimes, using a custom-built pressure- and volume-imposed rheometer. Our results, expressed in terms of the effective friction coefficient and packing fraction, demonstrate that suspensions of hard spheres exhibit continuous shear thickening when inertia becomes significant at a transitional Stokes number of 10, independent of the packing fraction. These findings can be extended to a Soft Granular Rheology model by renormalizing the volume fraction and friction coefficient to pressure-dependent values, incorporating both viscous and inertial stress scales. SGranR successfully captures the rheological behavior, showing an approximate collapse into two branches through power-law scaling relative to the distance from the jamming point: (i) above the jamming transition, where the behavior is described by a generalized Herschel-Bulkley law with yield stress and shear thinning, and (ii) below the jamming point, where the behavior follows a critical power law, with shear thinning near the jamming point.

DY 19.3 Tue 10:15 HÜL/S186

granular drag towards zero gravity — •tianhui liao[1], tivadar pongo[1], jinchen zhao[1], simeon vöelkel[2], valentin dichtl[2], raúl c. hidalgo[3], and kai huang[1,2] — [1]Collective Dynamics Lab, Division of Natural and Applied Sciences, Duke Kunshan University, 215306 Kunshan, Jiangsu, China — [2]Experimentalphysik V, Universität Bayreuth, 95440 Bayreuth, Germany — [3]Department of Physics and Applied Mathematics, University of Navarra, 31009 Pamplona, Spain

The role of gravity on the drag force F_d acting on a projectile impacting granular media is investigated experimentally using embedded inertial measurement unit (IMU) sensor and numerically with discrete element method (DEM) simulations. As gravity approaches zero, the inertial drag plays a dominating role, leading to qualitatively different scaling laws and cavity dynamics. Similarly to fluid dynamics, we define a dimensionless granular drag coefficient C_gd, which yields a constant of $\approx 1.2 \pm 0.2$ under microgravity, and a term inversely proportional to the impact velocity v_0 is added in the presence of gravity. This connection to fluid drag sheds light not only on a wide range of applications of granular media in space exploration, but also on drag force in non-Newtonian fluids from a first principle perspective.

DY 19.4 Tue 10:30 HÜL/S186

Impact of Roughness on Packing Fraction — •Adrien Luyckx and Eric Opsomer — GRASP Institute, Liege University, Belgium

This study investigates the impact of particle rugosity on the mechanical properties of piles using computational methods. We focus on smooth, non-convex particles (rod, cross, and star shapes) approximated via multisphere approach. Our research introduces the concepts of macro-rugosity, which increases as we progress from rod to cross to star shapes, and meso-rugosity, which is adjusted by varying the number of spheres composing the particles. Key findings include: (1) A limited meso-rugosity is sufficient to capture the mechanical properties of a pile, such as its height. (2) As macro-rugosity increases, the required meso-rugosity decreases. These results demonstrate that particle representation can be optimized by balancing meso-rugosity with the imposed macro-rugosity, significantly reducing computational demands. Our findings contribute to the ongoing efforts in enhancing the efficiency and accuracy of discrete element methods (DEM) in modeling complex particle systems.

DY 19.5 Tue 10:45 HÜL/S186

Tangential forces govern viscous-inertial transition in dense frictional granular suspensions — •Sudarshan Konidena[1], Franco Tapia[1], Alireza Khodabakhshi[1], Élisabeth Guazzelli[2], Pascale Aussillous[3], and Bernhard Vowinckel[1] — [1]Institute of Urban and Industrial Water Management, Technische Universität Dresden, 01062 Dresden, Germany — [2]Université Paris Cité, CNRS, Matière et Systèmes Complexes (MSC) UMR 7057, Paris, France — [3]Aix Marseille Université, CNRS, IUSTI, Marseille, France

Using pressure-imposed rheology, we carry out particle-resolved simulations to study dense suspensions of frictional suspensions as they move from a viscous regime into an inertial one. By independently tuning the liquid viscosity, the shear rate, and the confining granular pressure, we determine that the onset of this transition always appears at a Stokes number near 8 and does not depend on the volume fraction. A key outcome is that the shear stress evolves toward its inertial behavior more slowly than the particle pressure. This delayed response arises from the combined influence of tangential contact forces and lubrication interactions, which govern how frictional particles gradually switch from predominantly rolling motions to predominantly sliding ones. Although the Stokes number dictates the overall shift, the degree of proximity to jamming also plays a role. We further explore how stronger inter-particle friction alters the characteristics of the viscous*inertial transition.

15 min. break

DY 19.6 Tue 11:15 HÜL/S186

Rheology of Granular Sediment Beds from Dense to Creeping Regimes — •Bernhard Vowinckel[1], Pascale Aussillous[2], and Élisabeth Guazzelli[3] — [1]Institute of Urban and Industrial Water Management, Technische Universität Dresden, 01062 Dresden, Germany — [2]Aix Marseille Université, CNRS, IUSTI, Marseille, France — [3]Université de Paris, CNRS, Matière et Systèmes Complexes (MSC) UMR 7057, Paris, France

We investigate the rheology of sheared sediment beds using grain-resolved direct numerical simulations supported by experimental data. Poiseuille and Couette configurations are examined, extending monodisperse systems to polydisperse beds with diameter ratios up to 10. The simulations provide depth-resolved stress profiles, fluid-particle momentum exchange, particle volume fraction, and granular pressure. For monodisperse beds, shear and normal viscosities and the effective friction coefficient follow established correlations, with a critical particle volume fraction of about 0.3 marking the transition from dense to dilute regimes. In the dilute transport layer, hydrodynamic interactions are screened and the effective viscosity approaches the Einstein relation. For polydisperse mixtures, we generalize $\mu(J)$-rheology by linking its parameters to the maximum packing fraction, achieving good agreement with reference data. Access to very low viscous numbers shows that the friction coefficient in the creeping regime tends to a finite quasi-static value, reducing the critical friction coefficient by a factor of three. These findings refine closure relations for two-phase sediment transport models.

DY 19.7 Tue 11:30 HÜL/S186

Elastic Soft-Shell Packings — •Eric Opsomer and Nicolas Vandewalle — University of Liege, Liege, Belgium

The evolution of pressure at the bottom of a two-dimensional pile of thin elastic rings is investigated for increasing filling height of the system. Due to the soft nature of the particles, contact forces are only weakly deviated which causes a delay of the pressure saturation that is commonly observed in hard grain system. More importantly, for large fillings, an abrupt transition within the structure of the granular pile is encountered once the surrounding pressure leads to the buckling of the rings composing the bottom layers of the pile. The latter transition can be predicted based on the mechanical properties of the thin rings and the global evolution of pressure can be modeled by extending Janssen's model to an effective two-phase granular media.

DY 19.8 Tue 11:45 HÜL/S186

Rheology of dense suspension: the effects of wall-boundaries on viscous-inertial transition — •Alireza Khodabakhshi, Sudarshan Konidena, Franco Tapia, and Bernhard Vowinckel — Institute of Urban and Industrial Water Management, TU Dresden, Dresden, Germany

The transition from the viscous to the inertial regime in dense suspensions is still not fully clarified. Volume-imposed rheometers with fixed-gap walls offer valuable information by reporting shear and normal stress as functions of shear rate, yet the influence of confining boundaries, especially in narrow-gap configurations relevant to industrial and natural flows, remains insufficiently explored. In this study, we perform particle-resolved Direct Numerical Simulations (pr-DNS) of dense non-Brownian suspensions sheared between rough walls in a confined volume-imposed rheometer. The simulations capture the overall viscous-inertial trend reported in recent experiments and reproduce the observed weakening of the effective friction coefficient during the transition. We analyze multiple cases by varying wall roughness and rheometer height, showing that both parameters strongly affect stress levels by altering particle layering. All configurations develop pronounced layering, but the case with the roughest wall and weaker confinement enhances inter-layer mixing, producing higher stress levels. After sufficient strain, this configuration evolves toward a more ordered, low-mixing state, reducing stress to values similar to the other cases. Despite variations in stress magnitude, all cases follow a consistent viscous-inertial transition.

DY 19.9 Tue 12:00 HÜL/S186

Two time scales drive the formation of transient networks in a ferrogranular experiment - and how to control them — •Ali Lakkis[1], Matthias Biersack[1], Oksana Bilous[2], Sofia Kantorovich[2], and Richter Reinhard[1] — [1]Experimentalphysik 5, Universität Bayreuth — [2]Fakultät für Physik, Universität Wien

We are reporting experiments on the aggregation dynamics in a horizontally confined granular mixture composed of glass and magnetized steel spheres under vertical vibration. Upon a sudden decrease of the shaking amplitude, magnetized particles undergo a transition from a dispersed to an aggregated state. For deep quenches, a transient, percolating network of magnetized spheres rapidly emerges and gradually coarsens into compact clusters. In contrast, moderate amplitude reductions lead directly to dense cluster formation without intermediate networking. Using structural and network metrics such as coordination number and its mean value, we identify two characteristic timescales: a fast one governing the head-to-tail chaining typical of dipolar hard spheres (DHS), and a slower one corresponding to the restructuring into compact aggregates [1]. This progression is driven by the intrinsic susceptibility of the beads but is challenged by inter-sphere-friction. Thus, the employed susceptible dipolar hard spheres (SDHS) are a minimal model for phase separation with two intrinsic time scales in only one constituent.

[1] A. Lakkis, M. Biersack, O. Bilous, S. S. Kantorovich, R. Richter, *Soft Matter* (2025) doi:10.1039/d5sm00726g

DY 19.10 Tue 12:15 HÜL/S186

CT-resolved flow-induced particle migration in pipe bends during concrete pumping — •Daniil Mikhalev[1], Moritz Kluwe[2], Rüdiger Schwarze[2], and Viktor Mechtcherine[1] — [1]TU Dresden, Institute of Construction Materials, 01187 Dresden — [2]TU Bergakademie Freiberg, Institute for Mechanics and Fluid Dynamics, 09599 Freiberg

In this study, we investigate how the granular microstructure of pumped fresh concrete evolves as the suspension passes through a 90° pipe bend. The material is pumped under realistic operating conditions and allowed to harden in situ. To identify shear-dominated regions, a dyed low-viscosity premix is introduced as a passive tracer. Hardened bend sections are then analysed using high-resolution X-ray computed tomography. Segmentation of individual grains, voids, and tracer regions enables spatial statistics of solid volume fraction, grain-size distributions, air-void patterns, and shear-zone geometry along the inflow-bend-outflow transition.

Preliminary results reveal measurable deviations from the symmetric plug - lubrication-layer structure known from straight pipe flow, including radial and azimuthal segregation and restructuring of both solid and air phases. The combined tracer-based and tomographic approach provides a foundation for linking experimentally resolved microstructure with continuum suspension models and particle-migration theories in complex geometries.

General Discussions