DY 48: Granular Matter and Contact Dynamics

Time: Thursday 15:00–17:00 Location: BH-N 128

DY 48.1 Thu 15:00 BH-N 128

Columnar Structures of Spheres: Fundamentals and Applications — •Jens Winkelmann[1] and Ho-Kei Chan[2] — [1]Trinity College Dublin, Dublin, Ireland — [2]Harbin Institute of Technology, Shenzhen, China

Columnar structures, many of which are helical, refer to dense cylindrical packings of particles. They are ubiquitous; for example, they exist in the contexts of botany, foams, and nanoscience. There have been in-depth investigations of columnar structures of both hard spheres (e.g., ball bearings) and soft spheres (e.g., wet foams), through computer simulations, analytic derivations, or simple experiments. In this talk, I will present you an overview of the fundamentals and applications of such structures, based on our recently published book on this subject. I will review some of the theoretical and experimental methods employed to assemble such structures, and then discuss some of the latest findings related to the structural transitions and hysteretic behaviour of such systems.

DY 48.2 Thu 15:15 BH-N 128

Rheology of entangled assemblies of granular chains — Mehdi Habibi[1] and •Reza Shaebani[2] — [1]Wageningen University, The Netherlands — [2]Saarland University, Germany

We study the nonlinear rheology of random assemblies of granular chains under oscillatory shear. It is known that a narrow shear zone forms near the moving boundaries in a granular packing upon increasing the strain amplitude. We show that the presence of topological constraints between chains sharpens the transition and broadens the sher zone. Both the shear-zone width and the transition sharpness follow scaling laws as a function of chain length. Above the transition point, we observe shear stiffening behavior as a result of semiloop formation by chains. We also clarify the role of interparticle friction on the rheological response of the assembly.

DY 48.3 Thu 15:30 BH-N 128

Rheological properties of fluidized granular matter — •Marlo Kunzner[1], Olfa D'Angelo[2], Till Kranz[3], and Matthias Sperl[1,3] — [1]Institut für Materialphysik im Weltraum, DLR Köln, Deutschland — [2]Institute of Multiscale Simulation, FAU Erlange, Deutschland — [3]Institut für Theoretische Physik, Uni Köln, Deutschland

Aerated granular media are important in several industrial processes; yet, their flow-behavior is poorly understood. On one hand, the well-known Geldart classification [1] divides granulates by their fluidization characteristics; on the other hand, the rheology of air-fluidized granular media has been recently investigated experimentally and theoretically [2], considering the fluidized bed as a homogeneous medium. We propose to link these two approaches by measuring flow curves for polydisperse particles of different diameter regimes ranging from 70*m to 420*m. We find different rheological regimes depending on fluidization velocity and shear-rate, including Newtonian at low shear rate and Bagnoldian shear-thickening at high shear rate. We support the rheometry by light scattering to gain insights on the microscopic behavior of the aerated granular media in the future. [1] Geldart, D "Types of Gas Fluiditation", 1973 [2] O. D*Angelo, A. Shetty, M. Sperl, and W. T. Kranz, *The manifold rheology of fluidized granular media,* 2023.

DY 48.4 Thu 15:45 BH-N 128

How to make Sense of Fluidized Bed Rheology using Shear Banding and Three Time Scales — •W. Till Kranz[1,2], Olfa D'Angelo[2,3], Olivier Coquand[2,4], Abhishek Shetty[5], and Matthias Sperl[2,1] — [1]University of Cologne, Germany — [2]DLR, Germany — [3]University of Erlangen, Germany — [4]University of Perpignan, France — [5]Anton Paar, USA

The rheology of granular fluids is surprisingly rich if agitation by shear is combined with fluidization and comprises ordinary Newtonian rheology as well as shear thinning and shear thickening regimes. We will report on careful measurements of air-fluidized glass beads in a Taylor-Couette shear cell [1]. We will sketch a procedure to extract quantitative rheological information spanning all the rheological regimes and summarized in only a handful of physically meaningful parameters. Taking into account shear banding this approach embraces and extends the well known empirical μ-$\mathcal{I}$-rheology [2] of non-fluidized granular flows. Using simple arguments involving three relevant time scales, we will show how the seemingly complex rheology stems from intuitive and transparent physical principles [3].

[1] O. D'Angelo, A. Shetty, M. Sperl and W. T. Kranz, arXiv:2309.00413
[2] GDR Midi, EPJ E **14**, 341 (2004)
[3] O. Coquand, W. T. Kranz and M. Sperl, arXiv:2008.05931

DY 48.5 Thu 16:00 BH-N 128

Heating and cooling in a granular gas of spheres in microgravity — •Mahdieh Mohammadi[1,3], Torsten Trittel[1,3], Raul Cruz Hidalgo[2], Dmitry Puzyrev[3], Adrian Niemann[4], Ralf Stannarius[1,3,4], and Kirsten Harth[1,3] — [1]Department of Engineering, Brandenburg University of Applied Sciences, Magdeburger Str. 50, 14770 Brandenburg an der Havel,Germany — [2]Departamento de Física y Matemática Aplicada, Facultad de Ciencias , Universidad de Navarra, Pamplona, Spain — [3]MTRM, Otto von Guericke University Magdeburg, Universitätsplatz 2, 39106 Magdeburg, Germany — [4]Institute of Physics, Otto von Guericke University Magdeburg, Universitätsplatz 2, 39106 Magdeburg, Germany

We investigate the dynamic characteristics pertaining to the cooling and heating processes of particles in a microgravity environment. A comprehensive analysis, facilitated by simulations conducted across various regimes with a consistent restitution coefficient and varying friction coefficients, has been undertaken. The determination of characteristic times for the cooling and heating phases is established through an assessment of the system's dynamical parameters. Distinct trends are observed in the attitudes of mean translational and rotational energies within the ensemble of particles during both the cooling and heating phases.

DY 48.6 Thu 16:15 BH-N 128

Clustering of Magnetized Iron Granulate – Less is More Susceptible — •Ali Lakkis[1], Matthias Biersack[1], Oksana Bilous[2], Sofia Kantorovich[2], and Reinhard Richter[1] — [1]University of Bayreuth, Experimental Physics 5, Universitätsstrasse 30, 97440 Bayreuth, Germany — [2]University of Vienna, Faculty of Physics, Kolingasse 14-16, 1090 Vienna, Austria

We are exploring in experiments the aggregation process in a shaken granular mixture of glass and magnetized steel beads, filled in a horizontal vessel. After the shaking amplitude is suddenly decreased, the magnetized beads form a transient network that coarsens in time into compact clusters [1]. Recently it has been quantified how a homogeneous magnetic field B oriented in vertical direction impedes the emergence and growth of the networks [2]. Here we investigate how an increased volume fraction ϕ of the granulate accelerates the coarsening. Moreover, we explore the coarsening dynamics in the (ϕ, B)-control parameter space, and observe that low filling fractions are more susceptible to an increase of B than high ones [3].

[1] A. Kögel, R. Maretzki, E. S. Pyanzina, P. A. Sánchez, S. S. Kantorovich, R. Richter *Soft Matter*, 14 (2018) 1001.
[2] M. Biersack, A. Lakkis, R. Richter, O. Bilous, P. A. Sánchez, S. S. Kantorovich *Phys. Rev. E*, 108 (2023) 054905.
[3] A. Lakkis, M. Biersack, O. Bilous, S. S. Kantorovich, R. Richter, *J. Magn. Magn. Mater*, submitted (2023).

DY 48.7 Thu 16:30 BH-N 128

Magnetic Tubes - Instability of a Drug Deliverer — •Ingo Rehberg — Bayreuth University, Germany

Tubular assemblies of magnetic particles act as microrobots for cargo transport [1]. The magnetization of such tubes comes in two families: Circular magnetization is preferred for short tubes, and axial magnetization for longer ones [2, 3]. Introducing the strength of the outer dipole ring as an order parameter [4] in a numerical simulation unveils the nature of that transition from circular to axial states [5].

[1] Xiaoyu Wang et al., PNAS 120, e2304685120 (2023).
[2] Igor Stanković et al., Nanoscale 11, 2521 (2019).
[3] Adrien Wafflard et al., New J. Phys. 25, 063024 (2023).
[4] Simeon Völkel et al., JMMM 559, 169520 (2022).

[5] Ingo Rehberg, From Tetrahedra to Buckyballs - Examine 486 Dipole Clusters with a Single Python Animation. https://doi.org/10.5281/zenodo.10201571 (2023).

DY 48.8 Thu 16:45 BH-N 128

Exploring the impact of concentration and applied magnetic field on the diffusion coefficient of ferrogranulate: insights from computer simulations — •Oksana Bilous[1], Pedro Sánchez[1], Ali Lakkis[2], Reinhard Richter[2], and Sofia Kantorovich[1] — [1]Computational and Soft Matter Physics, University of Vienna, Vienna, Austria — [2]Experimental Physik, University of Bayreuth, Bayreuth, Germany

We study how an applied magnetic field affects the self-diffusion of magnetic particles in a ferrogranulate layer*a composite of glass and steel millimetre-sized particles on a shaken substrate. Initially, the system is maintained in a non-aggregated state through high shaking amplitude, followed by a step-like quench that induces particle aggregation and a slowdown. When an external magnetic field is applied perpendicular to the layer, aggregation is inhibited, prompting an investigation into its impact on particle diffusion. Molecular dynamics simulations model the ferrogranulate as a mixture of Stockmayer and repulsive spheres, with shaking amplitude mimicked by a thermostat. We find that at low applied field values, the system exhibits a bistable gas-liquid regime at high concentrations, while for stronger fields, the system shows no signs of a phase transition, significantly influencing the system dynamics.