DY 10: Granular Physics 2 - organized by Matthias Sperl (Köln)

Time: Monday 11:00–13:00 Location: DYc

DY 10.1 Mon 11:00 DYc

Particle shape-dependence of the stability properties of granular piles — •Steffen Richters-Finger and Stefan J. Linz — Institut für Theoretische Physik, Westfälische Wilhelms-Universität Münster, Germany

It is well known that the shape of particles has a major influence on the behavior of densely packed granular matter making it an important subject of interest for various applications. Multiple schemes for the numerical simulation of non-spherical particles have previously been proposed in the literature [1].

Applying a discrete function representation (DFR) approach for collision detection, we investigate the shape-dependence of the stability properties (e.g. critical angle of stability) of a granular pile in a two-dimensional discrete element model for a wide range of polar geometries generated by the so-called superformula [2].

[1] G. Lu, J.R. Third, C.R. Müller, Chem. Eng. Sci. **127**, 425-465 (2015).
[2] J. Gielis, Am. J. Bot. **90**, 333-338 (2003).

DY 10.2 Mon 11:20 DYc

Machine learning aided tracking of rod-like particles in 3D microgravity experiments on granular gases — •Dmitry Puzyrev, Kirsten Harth, Torsten Trittel, and Ralf Stannarius — Institute of Physics, Otto von Guericke University, Magdeburg, Germany

Granular gases are nonlinear systems which exhibit fascinating dynamical behavior far from equilibrium, including unusual cooling properties, clustering and violation of energy equipartition. Our investigation is focused on 3D microgravity experiments with dilute ensembles of rod-like particles, where the mean free path is substantially reduced as compared to gases of spherical grains of identical volume fraction [1]. Moreover, elongated particles provide the possibility to efficiently study the energy transfer between the translational and rotational degrees of freedom.

One particular problem is the reliable detection and tracking of the rods in 3D, especially at volume fractions beyond the very dilute limit. We have developed a Machine Learning aided approach [2] to the experimental data analysis which allows to recognize and track individual particles in ensemble.

[1] K. Harth et al., Free cooling of a granular gas of rodlike particles in microgravity, Phys. Rev. Lett., 120 (2018), 214301
[2] Puzyrev et al., Machine learning for 3D particle tracking in granular gases, Microgravity Sci. Technol., 32 (2020), 897

DY 10.3 Mon 11:40 DYc

Particle size dynamics in abrading pebble populations — •Janos Török[1,2], Andras Sipos[1,3], and Gabor Domokos[1,3] — [1]MTA-BME Morphodynamics Research Group, Budapest University of Technology and Economics — [2]Department of Theoretical Physics, Budapest University of Technology and Economics — [3]Department of Mechanics, Materials and Structures, Budapest University of Technology and Economics

Abrasion of sedimentary particles in fluvial and aeolian environments is widely associated with collisions encountered by the particle. Although the physics of abrasion is complex, purely geometric models recover the course of mass and shape evolution of individual particles in low and middle energy environments (in the absence of fragmentation) remarkably well. In this paper, utilizing results of this individual, geometric abrasion theory as a collision kernel, following techniques adopted in the statistical theory of coagulation and fragmentation, we construct the corresponding Fokker-Planck equation as the first model for the collision-driven collective mass evolution of sedimentary particles. Our model uncovers a startling fundamental feature of collective particle size dynamics: collisional abrasion may, depending on the energy level, either focus size distributions, thus enhancing the effects of size selective transport or it may act in the opposite direction by dispersing the distribution. This complex behaviour does not contradict existing geological observations on mass distributions.

DY 10.4 Mon 12:00 DYc

Applying Edwards' theory for a $2 + \epsilon$ dimensional frustrated granular system — •Sára Lévay[1], David Fischer[2], Ralf Stannarius[2], Ellák Somfai[3], Tamás Börzsönyi[3], Lothar Brendel[4], and János Török[1,5] — [1]Budapest University of Technology and Economics — [2]Otto von Guericke University — [3]Wigner Research Centre for Physics — [4]University of Duisburg-Essen — [5]MTA-BME Morphodynamics Research Group

Despite the inherent athermal features of granular materials, treating jammed granular systems in analogy to thermal equilibrium statistical mechanics was proposed by Edwards by using a volume ensemble of equiprobable jammed states. We introduce a simple system to analyze statistical properties of jammed granular ensembles to test Edwards' theory.

Identical spheres packed in a nearly two-dimensional thin geometrical confinement were studied in experiments and numerical simulations. When tapped, it evolves towards a ground state, but due to incompatible domain structures it gets trapped. Analytical calculations of the Edwards ensemble reproduce well our simulation results, which allows us to test Edwards' theory on a coupled system of two subsystems with different properties. We find that the joint system can only be described by a common compactivity if the stress equilibrium is also taken into account and the system is treated as a whole. The results show some counterintuitive effects, as the side with more order compactifies.

DY 10.5 Mon 12:20 DYc

Can machine learning help to identify variables of a granular theory? — •Ansgar Kühn, Song-Chuan Zhao, and Matthias Schröter — Max Planck Institute for Dynamics and Self-Organization, Göttingen

Presently, the best theory for predicting the number of contacts in a granular packing is using the local package fraction as its independent variable [1]. In order to go beyond this one-parameter approach, a more detailed description of the local geometry is given in the form of Minkowski tensors of the Voronoi cell. With this data as features, machine learning provides a more accurate prediction of contact numbers than [1]. Feature selection can be used to identify new variables most relevant for the prediction in order to expand the theory.

[1] Song et al. Nature, 453, 629–632 (2008)

DY 10.6 Mon 12:40 DYc

Flow in an hourglass: particle friction and stiffness matter — •Tamás Börzsönyi[1], Tivadar Pongó[1,2], Viktória Stiga[1], János Török[3], Sára Lévay[3], Balázs Szabó[1], Raúl Cruz Hidalgo[2], and Ralf Stannarius[4] — [1]Wigner Research Centre for Physics, H-1525 Budapest, Hungary — [2]Universidad de Navarra, Pamplona, Spain — [3]Institute of Physics BME, Budapest, Hungary — [4]Otto-von-Guericke-University, D-39106 Magdeburg, Germany

For usual granular materials the discharge rate from a silo is known to be time independent (constant flow rate). This is opposed to the case of a liquid for which the decreasing height leads to decreasing pressure, resulting in gradually decreasing flow rate during a discharge process. We performed laboratory experiments and numerical simulations with traditional (frictional hard) granular materials and grains with reduced surface friction and hardness. We show, that particle stiffness has a strong effect on the qualitative features of silo discharge. For deformable grains lowering the friction coefficient leads to a gradual change in the discharge curve: the flow rate becomes filling height dependent, it decreases during the discharge process. For hard grains the flow rate is much less sensitive to the value of the friction coefficient. For more details see Pongó et al., New J. Phys., (2021)