DY 1: Focus Session: Dense Granular Flow

Time: Monday 10:15–13:30 Location: HÜL 186

Invited Talk DY 1.1 Mon 10:15 HÜL 186

Dense Inclined Flows of Granular Materials — •James Jenkins — Cornell University, Ithaca, NY, USA

Hydrodynamic equations that result from classical kinetic theory, modified to incorporated energy lost in collisions, have been applied with success to dilute and moderately dense collisional granular flows. However, for inclined flows of identical sphere with concentrations above 49 per cent, their predictions do not agree with what is seen in numerical simulations and physical experiments. In this talk, we present a slightly modified hydrodynamic theory for inelastic spheres. The modification is the introduction of a length other than the diameter in the expression for the rate of collisional dissipation. This length is determined by a simple algebraic balance between the creation and destruction of particle chains. We apply the theory to dense collisional flows down both erodible and rigid, bumpy inclines and determine profiles of particle concentration, mean velocity, and fluctuation energy for steady, fully-developed flows of identical, frictional spheres. The profiles exhibit the features seen in the numerical simulations, and the integration of the energy balance through the depth of the flow results in an improvement of a velocity scaling employed in the interpretation of the physical experiments.

Invited Talk DY 1.2 Mon 10:45 HÜL 186

Shear localization and shear alignment in granular flows — •Tamás Börzsönyi[1], Balázs Szabó[1], Gábor Törös[1], Jim N. McElwaine[2], Robert E. Ecke[3], Sandra Wegner[4], and Ralf Stannarius[4] — [1]Research Institute for Solid State Physics and Optics, P.O. Box 49, H-1525 Budapest, Hungary — [2]Department of Applied Mathematics and Theoretical Physics, University of Cambridge, UK — [3]CNLS, Los Alamos National Laboratory, Los Alamos, NM 87545, USA — [4]Otto-von-Guericke-University, Institute of Experimental Physics, Universitätsplatz 2, D-39106 Magdeburg, Germany

Dense granular flows have been investigated experimentally and numerically in various geometries. For inclined plane flows we determine how the flow density decreases with increasing shear rate and also show, that the effective friction changes non-monotonously with increasing shear rate. This leads to a flow instability and shear localization. An other phenomenon is, that elongated grains get aligned in a simple shear flow. We study this flow alignment at low shear rates and find, that the alignment angle is independent of the shear rate, which is very similar to the flow alignment of liquid crystals. The shear induced orientation leads to a reduction of the effective friction of the material, which we determine experimentally.

T. Börzsönyi, R.E. Ecke and J.N. McElwaine, Phys. Rev. Lett. 103, 178302 (2009)

Invited Talk DY 1.3 Mon 11:15 HÜL 186

Flow of dense granular suspensions: an experimental study. — •Anke Lindner, Claire Bonnoit, and Eric Clement — PMMH-ESPCI, Paris, France

We study experimentally the flow of dense granular suspensions. The suspensions are made of mono-disperse, spherical, non-Brownian polystyrene beads immersed in density matched silicon oil. The volume fraction can be varied from 30 to 61%. We investigate the flow behaviour of these dense granular suspensions by the use of two complementary geometries: shear flow on an inclined plane and elongation flow during the detachment of a suspension droplet. We show that the inclined plane is a useful rheometer suited to explore the continuous transition from an effective viscous flow (high thicknesses) to dense "pseudo-granular" flow (low thicknesses). A mesoscopic length scale separates the two flow regimes and diverges when the volume fraction approaches the jamming limit. This set-up allows for measuring the viscosity directly up to volume fractions as large as 61%, which is impossible with a classical rheometer. In the case of the "pinch-off" experiments, we show that the elongation viscosity is identical to the one measured on an equivalent pure viscous liquid. Nevertheless, the final detachment regime is accelerated by the presence of grains. Moreover, we find a dynamical process independent of the grain concentration, but slightly dependent on the grain size.

15. min. break

Invited Talk DY 1.4 Mon 12:00 HÜL 186

Erosion and mobility in granular avalanches over sloping beds — •Anne Mangeney[1], Olivier Roche[2], Oldrich Hungr[3], and Nicolas Mangold[4] — [1]IPGP et Unviversité Paris Diderot, Paris, France — [2]LMV, IRD, Université de Clermont, Clermont Ferrand, France — [3]University of British Columbia, Vancouver, British Columbia, Canada — [4]LPGN, Université de Nantes, CNRS, France

We describe laboratory experiments of granular material flowing over an inclined plane covered by an erodible bed, designed to mimic erosion processes of natural flows. Two controlling parameters are the inclination of the plane and the thickness of the erodible layer. We show that erosion processes can increase the flow mobility of the grains by up to 40%. Erosion efficiency is shown to strongly depend on the slope of the topography. Entrainment begins to affect the flow at inclination angles exceeding a critical angle. Runout distance increases almost linearly as a function of the thickness of the erodible bed, suggesting that erosion is mainly supply dependent. Two regimes are observed during granular collapse: a first spreading phase with high velocity followed by a slow thin flow, provided either the slope or the thickness of the erodible bed is high enough. Surprisingly, erosion affects the flow mostly during the deceleration phase and the slow regime. The avalanche excavates the erodible layer immediately at the flow front. Waves are observed behind the front that help to remove grains from the erodible bed. Finally, simple scaling laws are proposed making it possible to obtain a first estimate of the deposit and emplacement time of a granular collapse over erodible bed.

Invited Talk DY 1.5 Mon 12:30 HÜL 186

Confined granular materials: stability, chute flows and grain motion — •Patrick Richard, Jean-Francois Metayer, Alexandre Valance, and Renaud Delannay — Institut de Physique de Rennes, Universite de Rennes I, UMR CNRS 6251, Campus de Beaulieu, 263 av. General Leclerc, 35042 Rennes cedex, FRANCE

We present experimental and numerical results of 3D confined granular materials. We address the issue of the role of the lateral boundaries on the stability and on the flow of such systems. In particular, we find that the presence of flat frictional lateral walls greatly alters the flow features as soon as the width of the flowing layer is of the order of the spacing between the walls or greater. The properties of such confined flow differ significantly from those of unconfined flows. The kinematic properties as well as the stress analysis are presented in details. The shear rate is constant and independent of inclination over much of the flowing layer. In the direction normal to the free surface, the solid volume fraction increases on a scale equal to half the flowing layer depth. Beneath a critical depth grains exhibit creeping and intermittent cage motion similar to that in glasses, causing gradual weakening of friction at the walls. These results underline the open problem of defining a single rheology for confined granular flows.

Invited Talk DY 1.6 Mon 13:00 HÜL 186

Convection and segregation of granular mixtures in almost filled containers — •Ralf Stannarius and Frank Rietz — Otto-von-Guericke-Universität Magdeburg, Institut für Experimentalphysik

When the free volume of granular material in a closed container goes to zero, dynamical degrees of freedom become more and more restricted, the system jams. Finally, agitation with external forces does no longer change the compact granulate structure. Interestingly, during this transition qualitatively new dynamical phenomena are observed. Slow processes become effective [1] that are otherwise absent or masked in containers with low fill level. They dominate dynamical processes and restructuring in almost full containers. We describe convection and segregation phenomena and their complex mutual interrelations. Respective to shaken containers with high fluidization, different symmetries of the dynamical structures as well as new coupling effects between segregation and dynamics are found.

[1] F. Rietz and R. Stannarius, Phys. Rev. Lett. 100, 078002 (2008).