DY 20: Focused Session: Pattern formation in colloidal and granular systems

Time: Thursday 9:30–12:45 Location: HÜL 386

Invited Talk DY 20.1 Thu 9:30 HÜL 386
Magnetic granular matter: from lattices to self-assembled swimmers — •Igor Aranson, Alexey Snezhko, Maxim Belkin, and Wai Kwok — Materials Science Division, Argonne National Laboratory, Argonne, IL60439

Fundamental mechanisms governing pattern formation and self-assembly in granular matter with complex interactions have been attracting enormous attention in the physics community. I will discuss novel dynamic patterns formed at magnetically driven granular matter: self-assembled magnetic surface swimmers: *magnetic snakes.* The snakes self-assemble from a dispersion of magnetic microparticles suspended on the liquid-air interface and subjected to an alternating magnetic field. The self-propulsion mechanism is related to a spontaneous symmetry breaking instability of the self-generated surface flows. We present a phenomenological model which reproduces observed features of the magnetic surface swimmers. In addition, formation of snakes is captured by hybrid molecular dynamics simulations of magnetic particles on the surface of fluid.

Topical Talk DY 20.2 Thu 10:00 HÜL 386
Non-equilibrium aggregates in confined systems of self-propelling colloidal rods — •Rik Wensink[1] and Hartmut Löwen[2] — [1]Department of Chemical Engineering, Imperial College London, South Kensington Campus, London SW7 2AZ, United Kingdom — [2]Institut für Theoretische Physik II: Weiche Materie, Heinrich-Heine-Universität-Düsseldorf, Universitätsstraße 1, D-40225 Düsseldorf, Germany

Swimming microorganisms, birds and fish often move collectively in large groups with spontaneous liquid crystalline order. Considerable research activity has been devoted in recent years to understand the origin of flocks and swarms in terms of simple models of self-propelled particles. In these models, "active" rods are driven by their own motor along the rod orientation axis and dissipate energy in the suspending medium. While the bulk behaviour of "active matter" is by now well understood, very little is known about the effects of system boundaries and confining geometries.

We have studied the non-equilibrium collective behavior of self-propelled colloidal rods moving in narrow channels by means of Brownian dynamics computer simulation and dynamical density functional theory. We observe an aggregation process in which rods self-organize into compact clusters that are transiently jammed at the channel walls. In the early stages of the aggregation process, fast-growing hedgehog-like wall clusters are formed which are virtually immobile. At later stages, most of these clusters dissolve and mobilize into nematized aggregates moving along the channel walls.

Topical Talk DY 20.3 Thu 10:30 HÜL 386
Beyond Faraday's crispations: nonlinear patterns of shaken granular material — •Christof Kruelle — Maschinenbau und Mechatronik, Hochschule Karlsruhe - Technik und Wirtschaft

When granular material is shaken both in horizontal and vertical direction simultaneously, as commonly done in vibratory conveyors that are well established in routine industrial production for controlled transport of bulk solids, the transported goods can exhibit a surprisingly large variety of surface patterns. For example, if a monolayer of glass beads is vibrated in a circularly manner in a narrow annular channel, a coexistence of a solidlike and a gaslike domain can be observed. The solid fraction decreases with increasing acceleration and shows hysteresis. The sharp boundaries between the two regions travel around the channel faster than the particles are transported. By using a molecular dynamics simulation we were able to extract the local granular temperature and number density. It was found that the number density in the solid phase is several times that in the gas, while the temperature is orders of magnitude lower.

If the number of particles is increased further, localized period-doubling waves arise. These solitary wave packets are accompanied by a locally increased particle density. The width and velocity of the granular wave pulses are measured as a function of the bed height. A continuum model for the material distribution, based on the measured granular transport velocity as a function of the bed thickness, captures the essence of the experimental findings.

15 min. break.

Topical Talk DY 20.4 Thu 11:15 HÜL 386
Archimedean-like Tilings on Decagonal Quasicrystalline Surfaces — •Clemens Bechinger, Jules Mikhael, and Laurent Helden — 2. Physikalisches Institut, Stuttgart, Germany

Monolayers on crystalline surfaces often form complex structures having physical and chemical properties strongly differing from those of their bulk phases. Such hetero-epitactic overlayers are currently used in nanotechnology and understanding their growth mechanism is important for the development of novel materials and devices. Compared to crystals, quasicrystalline surfaces exhibit much larger structural and chemical complexity leading e.g. to unusual frictional, catalytical or optical properties. Accordingly, deposition of thin films onto such substrates can lead to novel structures which may even exhibit typical quasicrystalline properties. Recent experiments indeed demonstrate 5-fold symmetries in the diffraction pattern of metallic layers adsorbed onto quasicrystals. Here we report a real-space investigation of the phase behaviour of a colloidal monolayer interacting with a quasicrystalline decagonal substrate created by interfering five laser beams. We observe a novel pseudomorphic phase which exhibits likewise crystalline and quasicrystalline structural properties. It can be described by an Archimedean-like tiling consisting of alternating rows of square and triangular tiles. The calculated diffraction pattern of this phase is in agreement with recent observations of copper adsorbed on icosahedral AlPdMn surfaces.

Topical Talk DY 20.5 Thu 11:45 HÜL 386
Injection in a confined granular suspension: from the Saffman-Taylor fingering instability up to flow inside a weakly jammed granular matrix. — Christophe Chevalier[2], Anke Lindner[1], Oeistein Johnson[1], and •Eric Clement[1] — [1]PMMH-ESPCI, Paris, France — [2]LCPC, Paris , France

The dynamics of fluid injection inside another one is a strong and debated issue in the context of many industrial and geophysical applications. When the displaced fluid is a complex fluid, the injection front is rarely stable and complex injection patterns usually form. These instabilities lead to strong and heterogeneous flows localisation and present a severe challenges to the fundamental understanding and accurate modelling, of multi-phases flow transfer. Here, we present recent experimental work on a simple experimental model of fluid injection inside a granular suspension confined in a Hele-Shaw cell. The density of the suspension can be varied continuously from low values up to the suspension jamming limit. The injected fluid can either be a non miscible fluid or a miscible one (like the suspension's surrounding fluid). This simple model allows a detailed investigation of many archetypal situations that extend the Saffman-Taylor fingering instability to the case of particulate fluids (Chevalier et al. Phys.Rev.Lett.(2007); Johnson et al. Phys.Rev.E(2008)) and address in a controlled way the case of hydro-fracturing in mechanically weak porous materials (Chevalier et al. JNNFM (2008)). Other collaborators : K-J.Maloy, E.Flekkoy, Univ.Oslo; R.Toussaint,J.Schmittbuhl, IPG Strasbourg.

Topical Talk DY 20.6 Thu 12:15 HÜL 386
Pattern Formation in Colloids Induced by Shear Flow and Electric Fields. — •Jan Dhont, Kyongok Kang, and Pavlik Lettinga — Forschungszentrum Juelich

Shear flow and electric fields are shown to induced non-patterned states in suspensions of colloidal rods (fd-virus particles). In part of the two-phase, paranematic-nematic region in the non-equilibrium phase diagram of colloidal rods under flow, regularly bands are formed that extend along the vorticity direction. Experiments indicate that the possible mechanism for the vorticity-banding instability is due to non-uniform elastic deformation of inhomogeneities that are formed during the initial stages of phase separation. This is similar to the Weissenberg effect in polymeric systems, where hoop stresses give rise to rolling flow as a result of the non-uniform deformation of polymer chains. Vorticity banidng is thus proposed to be similar to the Weissenberg effect, where the role of polymers is now played by inhomogeneities. The non-equilibrium phase/state behaviour of charged colloidal rods in electrric fields will be discussed, where the frequency is sufficiently low to polarize double layers. The polarized double layer around each of the rods interact with eachother, giving rise to a number of phases and dynamical states depending on the electric field amplitude and the frequency.