DY 40: Posters II

Time: Thursday 17:00–19:00 Location: P3

DY 40.1 Thu 17:00 P3

Mobility and motion in a restricted geometry of liquid crystalline membranes — •Sebastian Baumgarten, Alexey Eremin, and Ralf Stannarius — Institut für Experimentelle Physik, Universität Magdeburg, Universitätsplatz 2, 39106 Magdeburg

Flow phenomena in restricted geometries have been intensively studied in the last years with implications to different physical, chemical and biological systems. We report straightforward experiments where we observed the motion of inclusions in tilted free-standing films under gravity forces. Translational mobility of solid (silica beads) and liquid (water/glycerin droplets) microscopic inclusions in planar films of the smectic-A phase have been measured. The effects of the confinement (film size), and the role of the viscosity of the outer gas have been investigated. They will be discussed in terms of Saffman-Delbrück and Hughes-Pailthorpe-White (HPW) models.

DY 40.2 Thu 17:00 P3

Theoretical model for spontaneous imbibition of water in Vycor glass — •Zeinab Sadjadi and Heiko Rieger — Theoretische Physik, Universität des Saarlandes, 66041 Saarbrücken, Germany

We study theoretically the spontaneous imbibition, that is the capillary rise of water, in networks of hydrophilic silica pores with characteristic radii of 3-5 nm, which is realized by imbibition experiments with Vycor glass [1,2]. The latter is permeated by a network of interconnected pores which we model by a network of cylindrical pipes with random diameter and varying aspect ratio. We simulate the capillary rise of the liquid by solving the mass balance equations for ideal pipe flow at each node with the boundary pressure constraints given by the liquid reservoir on one side and the Laplace pressure at the moving menisci on the other side. We analyze the temporal evolution of the average height and width of the invasion front, as well as its morphological characteristics. Classical Lucas-Washburn law is expected for the time dependence of the height, varying theoretical predictions and experimental observations have been made for the tiem dependence of the front width, which we discuss in the light of our simulation results.

[1] Simon Grüner, Tommy Hofmann, Dirk Wallacher, Andriy Kityk and Patrick Huber, Phys. Rev. E 79, 067301 (2009).

[2] Simon Grüner and Patrick Huber, Phys.Rev. Lett 103, 174501 (2009).

DY 40.3 Thu 17:00 P3

Modelling a flexible sheet swimmer with stochastic rotation dynamics on graphic processing units — •Christian Schmeltzer and Holger Stark — TU Berlin

Artificial swimmers at low Reynolds numbers have attracted a lot of attention in recent years. Concepts for the propulsion of planar flexible structures have been demonstrated [1]. Here, we present an artificial sheetlike swimmer in a viscous environment. The sheet is modelled using vertices connected by spring potentials. To prevent it from crumbling, we applied bending potentials at each vertex site. The flow fields around the sheet are calculated with stochastic rotation dynamics (SRD). SRD is a multi-particle collision method capable of simulating mesoscale hydrodynamic effects with thermal fluctuations while being easy to implement. We first investigated the diffusion of the sheet and found it to follow Zimm dynamics. We then applied external forces normal to the sheet surface at neighboring edges but with opposite directions. The sheet starts to rotate and develops a helical shape which propels the sheet forward. The simulations with SRD are optimized for parallel computation on a graphic processing unit (GPU), which reduces the calculation time considerably. I will explain how the sheet is coupled to the SRD fluid and how the simulation speed increases due to parallel computing on the GPU.

[1] Garstecki et al. Propulsion of flexible polymer structures in a rotation magnetic field. J. Phys.: Condens Matter 21 204110 1-8 (2009).

DY 40.4 Thu 17:00 P3

Colloidal dynamics induced by phasonic drifts — •Justus Kromer[1], Michael Schmiedeberg[2], and Holger Stark[1] — [1]Institut für Theoretische Physik, Technische Universität Berlin, Germany — [2]Weiche Materie, Heinrich-Heine-Universität Düsseldorf, Germany

Phasons are unique to quasicrystals. These are non-periodic solids which nevertheless possess long-range positional and orientational order. Phasons correspond to global rearrangements of atoms in quasicrystals. Like phonons they are hydrodynamic modes since they do not increase the free energy in the long wavelength limit. The properties of phasons are still intensively discussed in the field [1].

We study the dynamics of a colloidal adsorbate induced by a phasonic drift in a quasicristalline substrate potential using Brownian dynamics simulations. The drift changes the potential landscape continuously where minima disappear and new ones are created. After the system has reached a non-equilibrium steady state, we find that the colloids perform a characteristic stick-slip motion. By slipping into new minimas, the colloids rearrange and thereby realize the phasonic drift in the adsorbate. Although individual particles move in different directions, the colloids exhibit a net drift that sensitively depends on the direction and velocity of the phasonic drift. Our observations help to get a deeper insight into the properties of phasonic displacements in colloidal as well as in atomic quasicrystals.

[1] C. L. Henley, M. de Boissieu, and W. Steurer, Philos. Mag. 86, 1131 (2006).

DY 40.5 Thu 17:00 P3

Das kapillare Brechungsproblem an einer stationären Wirbelschicht — •Walter Brett[1] und Wolfgang Ellermeier[2] — [1]TU Darmstadt — [2]TU Darmstadt

Das hier behandelte Problem entstammt der klassischen Hydrodynamik mit freien Oberflächen unter Schwerkraft- und Kapillaritätseinfluss. Zwei stationär unterschiedlich schnell strömende Flachwasserschichten bilden entlang ihrer Kontaktfläche eine Wirbelschicht (tangentiale Diskontinuität). Deren Stabilitäts-, Durchlass- und Reflexionsverhalten für Störungen kleiner Amplitude wird untersucht unter Einbeziehung der Analogien zwischen den entsprechenden Problemen der Strömung kompressibler Fluide und der Optik in bewegten Systemen. Ein Ausblick auf die nichtlinearen Aspekte wird gegeben.

DY 40.6 Thu 17:00 P3

Drawn meniscus in a precursor film model — •Mariano Galvagno and Uwe Thiele — Department of Mathematical Sciences, Loughborough University, Loughborough, LE11 3TU, UK

Dragging a flat plate out of a liquid bath may deposit a liquid film on it - a technique widely used in coating processes. To control the deposition one needs to understand the velocity-dependent shape of the meniscus. At high velocities U a macroscopic film is deposited – corresponding to the classical Landau-Levich problem [1]. For small U only a microscopic precursor film is deposited. Recent studies employ a slip model for contact line motion to discuss meniscus shapes and steady films of finite length [2].

We study the system with a precursor film model based on a Derjaguin pressure that describes partially wetting. As in [2] we find steady menisci at small U up to a saddle-node bifurcation at a limiting U_c. Depending on the inclination angle, in a small region below U_c, multiple steady solutions may exist. They correspond to menisci with a finite film-like 'foot'. The solution branches and the limits of the region of multiple steady solutions are traced employing numerical continuation [3].

We acknowledge support by the EU (PITN-GA-2008-214919).

[1] L. Landau, B. Levich, Acta Physicochim. URSS 17, 42 (1942) [2] J. H. Snoeijer et al., J. Fluid Mech. 579, 63 (2007); J. Ziegler et al., J. Eur. Phys. J. Special Topics 166, 177 (2009) [3] E. Doedel et. al, Int. J. Bifurcation Chaos, 1, 493 (1991); P. Beltrame, U. Thiele, SIAM J. Appl. Dyn. Syst. 9, 484 (2010)

DY 40.7 Thu 17:00 P3

Onset of Instabilities in Cooled Binary Fluids — •Jan-Hendrik Trösemeier and Jürgen Vollmer — Max Planck Institute for Dynamics and Self-Organization, 37073 Göttingen

Slowly cooling a binary fluid into the miscibility gap induces concentration gradients in the direction perpendicular to an interface separating the coexisting phases. When these gradients are too large the system becomes unstable against formation of droplets and/or convection.

The evolution of the system can be described by an appropriately adapted version of model H [1], i.e. a modified Cahn-Hilliard equation for the nonlinear diffusion of concentration coupled to the Navier-

Stokes equation. In this setting we investigate the onset of convective and diffusive instabilities. Linear stability theory provides the boundaries of the region with purely diffusive demixing, i.e. the threshold for the onset of nucleation [2] and for the onset of convection. Considering terms to quadratic order provides additional insight into the dynamics beyond the onset of stability.

[1] M.E. Cates, J. Vollmer, A. Wagner, & D. Vollmer, *Phil. Trans. Roy. Soc. (Lond.) Ser. A* **361** (2003) 793.
[2] J. Vollmer, *J Chem Phys* **129** (2008) 164502.

DY 40.8 Thu 17:00 P3

The Role of Convection in the Mpemba Effect — •Heiko Engelke and Jürgen Vollmer — Max Planck Institute for Dynamics and Self-Organization, 37073 Göttingen

Mpemba's cooling effect has long been a counter-intuitive puzzle [1]: Two identical samples of liquid are kept at different temperatures, then put into the freezer. The initally hotter sample is the one that freezes first.

Research in the late 20th century indicated that evaporative cooling and supercooling of the liquid contribute to this effect [2]. Surprisingly though, the role of convection for this effect has not thoroughly been addressed so far.

To fill in this gap we explore the flow patterns: After being put into the freezer the probe starts to cool inwards from the walls, a temperature gradient builds up, and convection arises. Depending on initial parameters, we see a transition between convective and diffusive cooling. This affects the temperature distribution at the arrest of the flow, and the freezing pattern.

For various viscosities, initial temperatures and geometric configurations the evolution of the temperature and the flow field are measured. The results are compared to numerical simulations.

[1] E. Mpemba & D. Osborne, *Phys Educ* **4** (1969) 172.
[2] M. Jeng, *Am J Phys* 74 (2006) 514.

DY 40.9 Thu 17:00 P3

Quantitative analysis of numerical estimates for the permeability of porous media from lattice-Boltzmann simulations — •Thomas Zauner[1] and Rudolf Hilfer[1,2] — [1]Institute for Computational Physics, University of Stuttgart, 70569 Stuttgart, Germany — [2]Institute for Physics, University of Mainz, 55099 Mainz, Germany

A quantitative error assessment for numerically calculated permeabilities with different simulation setups, numerical approximations and different LB-implementations, such as single- and multirelaxation time schemes is carried out [1]. From the error analysis we derive an optimized simulation setup, efficient LB-implementations and appropriate numerical approximations. This simulation setup is used to calculate the permeability of a digitized Fontainebleau sandstone as a benchmark. The resulting permeabilities for this sample, a refined sample and the extrapolated results are compared to other numerical permeability measurements in the literature [2]. The presented work illustrates some pitfalls that can lead to unreliable numerical permeability calculations from LB simulations. Further, it shows that a resolution and relaxation time dependent analysis together with an extrapolation scheme is necessary when using LB simulations to calculate permeabilities of stochastic porous media.

[1] A. Narváez, T. Zauner, F. Raischel, R. Hilfer, Journal of Statistical Mechanics, P11026, 2010.
[2] C. Manwart, U. Aaltosalmi, A. Koponen, R. Hilfer, J. Timonen, Phys. Rev. E, 66(1):016702, 2002.

DY 40.10 Thu 17:00 P3

Percolation in two phase flow in porous media on macroscopic scales — •Florian Doster[1] and Rudolf Hilfer[1,2] — [1]Institute for Computational Physics, University of Stuttgart, 70569 Stuttgart, Germany — [2]Institute for Physics, University of Mainz, 55099 Mainz, Germany

The standard model for multiphase flow in porous media on scales of centimeters to hectometers shows several deficiencies when compared with experiments. Fundamental parameter functions are not unique due to hysteretic and dynamic effects. Residual saturations cannot be predicted but are injected as parameters into the standard model. A macroscopic mixture theory for immiscible two phase displacement in porous media aims to cope with these deficiencies by taking into account the differences in percolating and nonpercolating phases. Recently first numerical solutions to the theory have been published [2,3]. Here, analytical and quasi-analytical solutions of a hyperbolic limit of the theory are presented. The results show that the degeneracy of states of the traditional theory is resolved within the new one. The results show that hysteresis in relative permeabilities is indeed reproduced inherently by the new theory. It is further indicated that dynamic effects in saturations and residual saturations are contained and that the representation of irreducible fluids by constant parameters in the traditional theory is questionable.

[1] R. Hilfer, Phys. Rev. E, 73, 016307 (2006)
[2] R. Hilfer and F. Doster, Trans. Por. Med., 82 (3), 507-519 (2010)
[3] F. Doster et al., Phys. Rev. E, 81, 036307 (2010)

DY 40.11 Thu 17:00 P3

The behavior of deformable droplet in the Hele-Shaw cell — •Erfan Kadivar and Martin Brinkmann — Max Planck Institute for Dynamics and Self-Organization, Bunsenstr. 10, D-37073 Göttingen, Germany

Motivated by recent experiments in microchannels, we studied the behavior of liquid droplets flowing in a Hele-Shaw cell by numerical simulation. The continuity equation and Darcy's law in combination with the discontinuity of the pressure at the curved interface of the droplet are used to obtain an integral representation of the pressure inside and outside of the droplet. The boundary element method is used to numerically determine the velocity field in both liquid phases as function of mobility and pressure gradient at periodic boundaries and to evolve the shape and position of the droplet in the microchannel.

According to recent experimental works, we used two different geometries; The first one is a rectangular microfluidic channel with thin width and specific length which has been expended abruptly. The second one is the microfluidic channel with the sinusoidal boundaries. We focused on the case that the droplet size is comparable to minimum width of channel. Therefore, we studied the droplet deformation when is flowing in the microchannel.

DY 40.12 Thu 17:00 P3

Spatially Modulated Thermal Convection — •Georg Freund, Werner Pesch, and Walter Zimmermann — Theoretische Physik I, Universität Bayreuth, 95440 Bayreuth

We study Rayleigh-Bénard convection (RBC) in a horizontal fluid layer heated from below and investigate theoretically different methods of imposing spatially periodic modulations.

It is well known that in (unmodulated) RBC a purely conductive state becomes unstable to convection, when the applied temperature gradient exceeds a critical value. The presence of spatial modulations breaks the translational symmetry leading to a convective state for any finite temperature difference between the top and bottom boundary. The spatial variation of such a 'forced' state follows the imposed modulation. However, these forced rolls are only stable for overcritical temperature gradients, if the wavenumber of the modulation lies in the vicinity of the critical wavenumber of unmodulated RBC. In this case one finds an imperfect-bifurcation scenario.

In recent experiments spatial modulations have been imposed by gluing block-shaped polymer stripes onto the lower boundary plate, while theoretical treatments exist for spatially varying temperature conditions on geometrically flat and to some extent on wavy-shaped boundary plates.

We solve the Oberbeck-Boussinesq equations directly and compare the various types of boundary conditions with each other. This allows for the first time a quantitatively consistent comparison to the experimental results.

DY 40.13 Thu 17:00 P3

Pattern evolution in a lifted Hele-Shaw cell — •Julia Nase[1,3], Didi Derks[2], and Anke Lindner[1] — [1]PMMH-ESPCI, 75231 Paris Cedex 5, France — [2]Graduate School of Engineering, Osaka University, Japan — [3]Fakutät Physik/DELTA, TU Dortmund, 44221 Dortmund

When a liquid is confined between two plates and the upper plate is lifted at constant speed, air penetrates into the liquid volume from the sides. For certain conditions, the contracting liquid does not form a stable circle, but air fingers develop. This instability is a variant of the Saffman-Taylor-instability and has the particularity to take place at changing control parameter. This situation is important for the understanding of debonding mechanisms in adhesion problems and might also give insight into growth mechanisms in biological systems.

We investigate the evolution of the finger pattern from the moment of destabilization to the final plate separation in a Newtonian liquid. At fixed time, the pattern is characterized by the number of fingers and the finger amplitude from tip to base. Starting from a variation of the parameters lifting speed v_0, initial gap width b_0, cell radius R_0,

and fluid viscosity η, we investigate in depth the influence of these parameters on the pattern coarsening.

At each moment, we distinguish stagnant and growing fingers. We show that the number of growing fingers is well described by a purely linear theory. Surprisingly, this description is also valid at late times where the linear prediction usually is expected to fail. The total number of fingers and the amplitude, however, are determined by the exact experimental conditions, particularly by the cell geometry.

DY 40.14 Thu 17:00 P3

Statistical properties of turbulent Rayleigh-Bénard convection — •Johannes Lülff, Michael Wilczek, and Rudolf Friedrich — Institut für Theoretische Physik, Westfälische Wilhelms-Universität Münster

We use PDF methods to analyze turbulent Rayleigh-Bénard convection. The equations governing the PDFs are derived, and occuring unclosed terms are estimated from DNS data. For this DNS, we developed an easy-to-implement numerical scheme using penalization techniques.

DY 40.15 Thu 17:00 P3

Adaptive de-trending and stochastic analyisis of wind time series. — •Allan Morales — Universität Oldenburg

Offshore horizontal wind speed time series are de-trended using an innovative so-called adaptive de-trending algorithm. The de-trended, turbulent fluctuating signal is analyzed and modelled with a one dimensional Langevian Equation. We show how this easy model is able to reproduce some basic statistical properties of the original turbulent signal.

DY 40.16 Thu 17:00 P3

Adaptive de-trending and stochastic analyisis of wind time series. — •Allan Morales — Universität Oldenburg

Offshore horizontal wind speed time series are de-trended using an innovative so-called adaptive de-trending algorithm. The de-trended, turbulent fluctuating signal is analyzed and modelled with a one dimensional Langevian Equation. We show how this easy model is able to reproduce some basic statistical properties of the original turbulent signal.

DY 40.17 Thu 17:00 P3

Resistance in percolating quasi 1D and 2D networks of nanofibers — •Milan Žeželj, Igor Stanković, and Aleksandar Belić — Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia

The scaling laws describing the conductivity in random networks of straight conducting nanofibers are derived from percolation theory and verified in numerical simulations. The applicability of the scaling laws to complex structures of interconnected networks of carbon nanofiber films and thick 1D wires is investigated in mesoscopic simulations. The current transfer in composite materials is found to be strongly enhanced by self-organization of nanofibers. The electrical conductivity of nanofiber films varies by orders of magnitude depending on the aspect ratio of the nanofibers, density and their structural arrangement in the material.

DY 40.18 Thu 17:00 P3

Shearing granular media: from elasticity to compaction — •Jean-Francois Metayer[1], Elie Wandersman[2], Martin Van Hecke[2], and Matthias Schroeter[1] — [1]MPI for Dynamics and Self-organization, Goettingen, Germany — [2]University of Leiden, Netherland

A granular system is able to behave like a solid (a sand pile for example) or like a liquid depending on the deformation imposed on the material.

Using rheometry measurements we investigate the response of a granular bed to an imposed deformation or an imposed stress as a function of its packing fraction. We observed different regimes: elastic, plastic behaviors, flow regime and finally compaction.

The dependence of these regimes on the packing fraction and on the pressure allows us to delineate the phase diagram of granular media.

DY 40.19 Thu 17:00 P3

Football in the rain - Rebound of balls from wetted ground — •Frank Gollwitzer[1], Kai Huang[1], Ingo Rehberg[1], and Christof A. Krülle[1,2] — [1]Experimentalphysik V, Universität Bayreuth, D-95440 Bayreuth, Germany — [2]Maschinenbau und Mechatronik, Hochschule Karlsruhe - Technik und Wirtschaft, D-76133 Karlsruhe, Germany

Considering the loss of energy when a solid particle hits hard on a flat surface and rebounds back into the air dates back to I. Newton who defined the coefficient of restitution for this inelastic collision as the ratio of the rebound vs. the impact velocity. Since the theoretical treatment of this complex phenomenon is difficult, experimental data are needed for comparison with elastomechanical models. It is known that the restitution coefficient depends on various parameters like impact velocity, size of the balls, materials involved, etc. Here we present results of an experimental investigation of the multiple collisions of a solid sphere hitting a hard surface wetted with liquid of various properties. For example, it is observed that the rebound occurs only above a critical approach velocity. From this, the energy needed to break the capillary bridge between ball and ground can be deduced.

DY 40.20 Thu 17:00 P3

Geometrical structure of spheres around Random Close Packing — •Frank Rietz[1,2], Charles Radin[3], Harry L. Swinney[3], and Matthias Schroeter[2] — [1]Univ. of Magdeburg — [2]MPI Dynamics & Self-Organization Goettingen — [3]Univ. of Texas at Austin

The name Random Close Packing refers to the experimental observation that some ways of packing of monodisperse beads (like vertical vibration or sedimentation) can't exceed a volume fraction of ≈64%. There are several competing theories trying to explain this phenomenon and it is still unclear how to correctly define the Random Close Packing density. The three-dimensional distribution of particles below and above Random Close Packing is investigated. We match the index of the surrounding liquid to provide access to the interior of the granular bed. We measured local packing densities and order parameter by means of Voronoi cells. This allows us to comment on the question if Random Close Packing is well defined.

DY 40.21 Thu 17:00 P3

The "Minimal Model 2.0": An accurate and efficient continuum description of sand dune formation — •Marc Lämmel, Daniel Rings, and Klaus Kroy — Institut für Theoretische Physik, Universität Leipzig, Germany

The so-called "minimal model" [1] is a continuum model of aeolian sand transport that can explain the formation and migration of sand dunes in the desert. What makes it conceptually and practically very appealing is that it captures the essential physical mechanisms while being computationally simple. Yet, recent research has demonstrated certain shortcomings of this popular model. Comparing the predicted dependence of the saturated sand flux on the wind speed with wind tunnel observations reveals a systematic deviation of that quantity: For stronger winds the model overestimates the flux significantly.

Here we show that a systematically improved version of the minimal model can be derived by considering two species of trajectories, similar to what has been proposed in Ref. [2]: low-energy reptating grains and high-energy saltating grains. The resulting predictions are in remarkable agreement with flux data from various wind tunnel measurements.

[1] G. Sauermann, K. Kroy, and H. J. Herrmann (2001, Aug). Continuum saltation model for sand dunes. Phys. Rev. E 64 (3), 031305.

[2] B. Andreotti (2004). A two-species model of aeolian sand transport. Journal of Fluid Mechanics 510, 4770.

DY 40.22 Thu 17:00 P3

3D particle tracking with a microwave radar setup — •Kai Huang[1,2] and Stephan Herminghaus[2] — [1]Experimentalphysik V, Universität Bayreuth, D-95440, Germany — [2]Max Planck Institute for Dynamics and Self-organization, Bunsenstr. 10, 37073 Göttingen, Germany

Granular matter is an agglomeration of macroscopic particles, which offers the opportunity to trace its dynamical behavior down to the mobility of individual particles. However, particle tracking in three dimensions, especially in an opaque medium such as a densely packed granular pile, is far from trivial. Here we introduce a microwave radar setup designed to trace a metallic particle in real time. The method is based on the phase shift between transmitted and reflected microwave signals, which are recorded by means of three receiver antennas. The tracing algorithms and first experiments to calibrate the setup will be presented.

DY 40.23 Thu 17:00 P3

Granular Anisotropic Gases — •Kirsten Harth[1], Stephan Höme[2], Ulrike Kornek[1], Ulrike Strachauer[1], Torsten Trittel[1], Karl Will[3], and Ralf Stannarius[1] — [1]Institut für experimentelle Physik, Otto-von-Guericke Universität Magdeburg, Deutschland — [2]Institut für Automatisierungstechnik, Otto-von-Guericke Universität Magdeburg, Deutschland — [3]Institut für Elektronik, Signalverarbeitung und Kommunikationstechnologie, Otto-von-Guericke Universität Magdeburg, Deutschland

Granular materials accompany us from early childhood days - but they still retain lots of unsolved challenges for grown-up scientists and engineers. They can exhibit states similar to gases, fluids and solids. So far, most experiments and theoretical investigations focussed on spherical or irregularly shaped particles.

We study a granular gas of elongated cylindrical particles a few millimetres in length under microgravity conditions. Our fully automatic setup consists of a translucent box with shaking walls, which is monitored with digital cameras from two perspectives. We will present first results from our sounding rocket flight. From the video data, the three-dimensional motion of the particles can be reconstructed, to analyze typical statistical quantities of the granular dynamics.

DY 40.24 Thu 17:00 P3

Parallelization of 2D Contact Dynamics in the simulation of granular media — •Zahra Shojaaee, Mohammad Reza Shaebani, Lothar Brendel, János Török, and Dietrich Wolf — University of Duisburg-Essen, Duisburg, Germany

Contact Dynamics (CD) is an effective discrete element method to simulate systems consisting of a large number of particles with multiple contacts such as granular matter. We simulate non cohesive hard discs with coulomb friction. CD uses an iterative method to calculate the contact forces, which fulfill the convergence criteria. To preserve reasonable computational time specially for large dense systems we have parallelized our CD code using open MPI. In contrast to the parallel MD method a large amount of communication between the processors is needed to calculate the contact forces in CD method. That is an important reason to pay more attention to the domain decomposition method. We have used a topological hierarchical domain decomposition method and an adaptive load balancing scheme, which aim to minimize the standard deviation of the real CPU time of all processors. The main challenge is to handle the iterative force calculation process in an optimal way. We investigate the performance of the iterative force calculation scheme, as well as the overall performance of the parallel code. Optimizing the communications between the processors results in a code which fulfills a good linear scaling also for a large number of processors. The solution remains stable until a critical number of processors depending on the system size, which deals with the weak point of CD method not bearing a parallel updating of contact forces.

DY 40.25 Thu 17:00 P3

Transition from attractive to repulsive Casimir-like forces in granular media — •reza shaebani[1], jalal sarabadani[2], and dietrich wolf[1] — [1]Department of Theoretical Physics, University of Duisburg-Essen, 47048 Duisburg, Germany — [2]Department of Physics, University of Isfahan, Isfahan 81746, Iran

We investigate the effective long-range interactions between intruder particles immersed in a randomly driven granular fluid. The effective force between two intruders, induced by the fluctuations of the hydrodynamic fields, is attractive when the volume fraction of the granular fluid is sufficiently high. However, a crossover from attraction to repulsion occurs as the volume fraction decreases. This behavior can be explained by two competing dynamical effects, resulting in a non-uniform collision distribution around the intruders. We present the phase diagram of the transition with three control parameters: the volume fraction, the distance between the intruders, and the restitution coefficient. Our results reveal that the force is proportional to the steady-state temperature and grows logarithmically with increasing the system size in two dimensions. Moreover, by increasing the number of intruders, we verify that the fluctuation-induced interaction is not derived from a pair-potential. These results shed new light on the mechanisms of segregation in granular media.

DY 40.26 Thu 17:00 P3

Influence of polydispersity on the static properties of granular materials — •reza shaebani[1], mahyar madadi[2], stefan luding[3], and dietrich wolf[1] — [1]Department of Theoretical Physics, University of Duisburg-Essen, 47048 Duisburg, Germany — [2]Department of Applied Mathematics, The Research School of Physics and Engineering, The Australian National University, Canberra 0200, Australia — [3]Multi Scale Mechanics (MSM), TS, CTW, Universiteit Twente , P.O. Box 217, 7500 AE Enschede, Netherlands

We study the effect of polydispersity on the macroscopic physical properties of granular packings in two and three dimensions. A mean-field approach is developed to approximate the micro-scale quantities that are linked to the macroscopic ones. We show that the trace of the fabric and stress tensors are proportional to the mean packing properties (e.g. packing fraction, average coordination number and average normal force) and correction factors which depend only on the moments of particle size distribution. Similar results are obtained for the elements of the stiffness tensor in the linear response regime. In order to compare the analytical results with numerical simulations, static homogeneous packings of particles are generated by means of the contact dynamics method. Our theoretical predictions are in good agreement with the simulation results.

DY 40.27 Thu 17:00 P3

Coarsening in granular segregation, an entropic approach — •Tilo Finger[1], Matthias Schröter[2], and Ralf Stannarius[1] — [1]Otto-von-Guericke-University-Magdeburg — [2]MPI for Dynamics and Self-organization Göttingen

When one fills a binary mixture in a cylindrical drum, one observe size segregation after agitation by horizontal rotation. This experiment has become a classic in granular physics. Segregation takes place on different time scales. At first, a radial segregation of the large and small particles is observed. This process is often followed by an axial segregation into band patterns. Gradual merging of the bands leads to an almost complete demixing on long time scales [1]. So far, the nature of this coarsening process is not understood. Here we present an X-ray tomography study where we visualize the tree-dimensional particle distribution in the cylinder. Our experiments aim at the confirmation of an increase of configurational entropy [2] during the coarsening process.

[1] T. Finger et al., PRE 74, 031312 (2006)
[2] S.F. Edwards & R.B.S. Oakeshott, Physica A 157, 1080 (1989)

DY 40.28 Thu 17:00 P3

A contact model for the yielding of caked granular materials — •János Török[1], Lothar Brendel[1], Roman Kirsch[2], and Ulrich Bröckel[2] — [1]Facultät für Physik, Universität Duisburg-Essen, Duisburg, Deutschland — [2]Fachhochschule Trier, Umwelt-Campus Birkenfeld, Deutschland

We present a visco-elastic coupling model between caked spheres, suitable for DEM simulations, which incorporates the different loading mechanisms (tension, shear, bending, torsion) in a combined manner and allows for a derivation of elastic and failure properties on a common basis. In pull, shear, and torsion failure tests with agglomerates of up to 10000 particles, we compare the failure criterion to different approximative variants of it, with respect to accuracy and computational cost. The macroscopic elastic behavior and failure properties of the agglomerates can be derived from the microscopic quantities which allows the scaling of all simulation results. The used method also gives also insight into the relative relevance of the different contact load modes.

DY 40.29 Thu 17:00 P3

Anisotropic elasticity in a frictional packing of disks — •Jens Boberski[1], Reza Shaebani[1], Tamás Unger[2], and Dietrich Wolf[1] — [1]Fakultät für Physik, Universität Duisburg-Essen, 47048 Duisburg, Germany — [2]Institute of Physics, Budapest University of Technology and Economics, 1111 Budapest, Hungary

Granular materials, when sheared, can evolve anisotropies due to the opening of contacts in a preferred direction. The opening of contacts leads to a change of the fabric and thus in the constitutive relation. The evolution of the contact distribution as well as the distribution of sliding contacts is predicted by assuming affine displacements of the disks. In a mean-field like approach the three elastic constants (bulk, shear and anisotropy moduli) are obtained by averaging over these distributions while assuming affinity. These predicted moduli are strain dependent and compared with results of DEM Simulations.

DY 40.30 Thu 17:00 P3

Capillary interaction between spherical particles: multi-body interactions and the effect of contact angle hysteresis — Ciro

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The mechanics of mixtures of sub-millimetric grains and liquids play an important role in process engineering and in the industrial scale production of many materials. At low liquid saturations, the cohesion in a granular assembly of spherical gains can be well explained by capillary forces induced by individual liquid bridges between neighboring beads. To account for the presence of larger liquid clusters, we numerically computed the capillary forces between three and more beads in contact to certain types of liquid clusters along with their interfacial energy and Laplace pressure. Besides these 'multi-body' interactions, we considered effects of contact angle hysteresis on the capillary interaction between two spherical particles. Both effects have an impact on the collective mechanical behavior of large particle assemblies and can be easily implemented in three dimensional contact dynamic simulations of frictional particles.

DY 40.31 Thu 17:00 P3

Monte Carlo Study of Mixed-Spin S=(1/2,1) Ising Ferrimagnets — •Walter Selke[1] and Jaan Oitmaa[2] — [1]Institut für Theoretische Physik der Phasenübergänge, RWTH Aachen, Germany — [2]School of Physics, University of New South Wales, Sydney, Australia

We investigate classical Ising ferrimagnets on square and simple–cubic lattices with exchange couplings between spins of values S=1/2 and S=1 on neighbouring sites and an additional single–site anisotropy term on the S=1 sites [1]. Based mainly on a careful and comprehensive Monte Carlo study, we conclude that there is no tricritical point in the two–dimensional case, in contradiction to mean-field predictions and recent series results. However, evidence for a tricritical point is found in the three–dimensional case. In addition, a line of compensation points is found for the simple–cubic, but not for the square lattice.

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DY 40.32 Thu 17:00 P3

The order parameter distribution of the 2D Ising model: A flat histogram Monte Carlo — •Anjan Prasad Gantapara[1] and Rudolf Hilfer[1,2] — [1]Institute for Computational Physics, University of Stuttgart, 70569 Stuttgart, Germany — [2]Institute for Physics, University of Mainz, 55099 Mainz, Germany

A high precision flat histogram Monte Carlo method is employed to calculate the order parameter distribution $p(m)$ of the 2D Ising model for a specified lattice size L and temperature T. Periodic, free and fixed boundary conditions are considered in our simulations. Universal forms of the $p(m)$ at temperatures below, above and at the ciritical point T_c are extracted and analyzed from the finite lattice simulations. The critical order parameter distribution is a function of the boundary condition unlike the $p(m)$ at temperatures away from T_c. Fat stretched exponential tails are seen in $p(m)$ for all the three boundary conditions at T_c corroborating previous analytical predictions [1]. The simulations provide the best converged critical order parameter universal scaling functions for periodic, free and fixed boundary conditions available at present.

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DY 40.33 Thu 17:00 P3

Examining the SLE properties of paths in the negative-weight percolation model — •Christoph Norrenbrock, Oliver Melchert, and Alexander K. Hartmann — Institut für Physik, Carl-von-Ossietzky Universität Oldenburg, Oldenburg (Germany)

We consider lattice spanning paths of total negative weight on two-dimensional lattice graphs, where edge weights are drawn from a distribution that allows for positive and negative weights. Each realization of the disorder consists of a random fraction $(1-\varphi)$ of bonds with unit strength and a fraction φ of bonds drawn from a Gaussian distribution with zero mean and unit width. This negative-weight percolation (NWP) problem is fundamentally different from conventional percolation [1]. To investigate this percolation problem by means of numerical simulations [2], one has to perform a non-trivial transformation of the original graph and apply sophisticated matching algorithms.

Here we study whether the geometry of these paths can be described in terms of Schramm-Loewner evolution. We exhibit that the paths do not verify the prediction of Schramm's "left passage formula" [3].

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[3] Schramm, O., Electr. Comm. Prob. 6 (2001)

DY 40.34 Thu 17:00 P3

Parallelising the transfer-matrix method in disordered systems using graphics processors — •Thomas Edwards and Rudolf Römer — University of Warwick, Coventry, United Kingdom

We study the disorder-induced Anderson localisation of a d-dimensional solid and compute the localisation lengths using the transfer matrix method (TMM), seeking a parallel implementation to run on graphics processing units (GPU's). In the TMM, a quasi one-dimensional bar of length $L \gg M$ is split into slices of size M^{d-1}. The Schrödinger equation is recursively applied such that the wave function at the future slice ψ_{i+1} is computed from the past and present slices, ψ_i and ψ_{i-1}. Reformulating the Schrödinger equation into a transfer matrix and repeating multiplications of these matrices at each slice gives the 'global transfer matrix', which maps the wave functions from one side of the bar to the other. The minimum eigenvalue computed from this matrix gives the localisation length. To obtain the minimum eigenvalue and prevent numerical instabilities resulting from the exponential increase in the eigenvalues, the eigenvectors must be re-orthonormalised after every few matrix multiplications. This takes a considerable amount of time, as does computing the transfer matrices themselves, making it crucial to efficiently parallelise the TMM code. To do this we use CUDA, NVIDIA's proprietary GPU programming language. The speed-up gained from running the code on NVIDIA GPU's is then analysed using the Karp-Flapp metric.

DY 40.35 Thu 17:00 P3

Worm algorithm in ordered and disordered media — •Martin Marenz and Wolfhard Janke — Institut für theoretische Physik, Universität Leipzig, Germany

The Worm algorithm is a Monte Carlo method that uses the high-temperature expansion series for simulating spin systems. It was introduced by Prokof'ev and Svistinov in 2001.

This work and a few other papers suggest that this algorithm does not suffer from critical slowing down. We investigated the critical behavior of the algorithm, which means we have calculated the dynamic critical exponents. This procedure has also been repeated for bond-disordered and site-diluted systems, therefore we expanded the algorithm to such systems and introduced several estimators for common observables. We could affirm that the critical slowing down has no practical influence for the Worm algorithm, this also holds true for disordered and diluted systems. Furthermore, we have introduced a reweighting method.

DY 40.36 Thu 17:00 P3

A new technique for complete enumeration of self-avoiding walks (SAWs) on percolation clusters — •Niklas Fricke and Wolfhard Janke — Institut für Theoretische Physik, Universität Leipzig, Germany

The critical behavior of SAWs on disordered lattices has been studied extensively in recent decades. Of particular interest is the situation at the percolation threshold where the fractal dimension changes. Unfortunately, the strong disorder poses a problem for Monte Carlo methods. Straightforward enumeration may benefit from the reduction of the number of paths at criticality, but the exponential increase still prohibits the study of longer chains. Here, a more effective enumeration scheme is presented. Exploiting the structural properties of the critical percolation cluster, it essentially removes the exponential increase in complexity. This permits studying walks of several hundred steps (involving effective enumeration of over 2^{100} chains) at or close to the percolation threshold.

DY 40.37 Thu 17:00 P3

Loop length distribution in higher dimensional negative weight percolation — •Gunnar Claussen, Oliver Melchert, and Alexander K. Hartmann — Institut für Physik, Carl-von-Ossietzky-Universität Oldenburg

We consider the negative weight percolation (NWP) problem [1] on large square and cubic lattice graphs, using disorder distributions that

allow for edge weights of either sign. We examine loops with negative weight, i.e. percolating and "small" loops, and vary the concentration ρ of negative edge weights. The NWP problem is fundamentally different from conventional percolation problems, e.g. it shows no transitivity, hence there is no simple definition of clusters. Thus, numerical studies on this loop model require a non-trivial transformation of the original graph and the application of sophisticated matching algorithms.

Here, we study the problem by numerical methods [2]. The phenomenon is examined for $\rho \leq \rho_c$, the critical point. We characterize the ensemble of "small" loops by the Fisher exponent τ, which describes the distribution of loop lengths at ρ through $n_\rho(l) \sim l^{-\tau} e^{-T_L l}$, and by the loop-size cut-off exponent σ, which determines the line tension T_L by $T_L \sim |\rho - \rho_c|^{1/\sigma}$. We compare our results to previous finite-size scaling analyses [3].

[1] O. Melchert and A.K. Hartmann, New J. Phys. 10 (2008) 043039
[2] A.K. Hartmann, *Practical Guide to Computer Simulations*, World Scientific (2009)
[3] O. Melchert, L. Apolo and A.K. Hartmann, Phys. Rev. E 81 (2010) 051108

DY 40.38 Thu 17:00 P3

The two-dimensional Ising spin glass at zero temperature — •Hamid Khoshbakht and Martin Weigel — Institut für Physik, KOMET 331, Johannes Gutenberg-Universität Mainz, Staudinger Weg 7, 55127 Mainz

Ground states for the Ising spin glass in two dimensions can be determined in polynomial time as long as periodic boundary conditions are applied in at most one direction. Using a recently proposed mapping to an auxiliary graph decorated with Kasteleyn cities, we determine ground states for systems with open-periodic boundary conditions for lattices of linear sizes up to $L = 9000$ and calculate defect energies as well as domain-wall lengths. Although the matching approach does not work for periodic-periodic boundaries, where less finite-size corrections are expected, using a windowing technique allows to determine quasi-exact ground-states for lattices up to $L = 3000$. For the case of bimodal couplings, a controlled perturbation method allows the matching approach to sample from the manifold of degenerate ground states without bias. Using the combination of these techniques, we arrive at high-precision estimates of the spin-stiffness exponent and domain-wall fractal dimension for Gaussian couplings, which are compared to a scaling relation conjectured from stochastic Loewner evolution. For bimodal couplings, our results allow for a first-time determination of the fractal dimension of domain walls.

DY 40.39 Thu 17:00 P3

Multicanonical and Wang-Landau simulations on GPU — •Taras Yavors'kii and Martin Weigel — Institut für Physik, KOMET 331, Johannes Gutenberg-Universität Mainz, Staudinger Weg 7, 55127 Mainz

Over the last couple of years it has been realized that the vast computational power of graphics processing units (GPUs) could be harvested for purposes other than the video game industry. This power, which is advertised to exceed that of current CPUs by a large factor, results from the relative simplicity of the GPU architectures as compared to CPUs, combined with a large number of parallel processing units on a single chip. To benefit from this setup for general computing purposes, the problems at hand need to be prepared in a way to profit from the inherent parallelism and hierarchical structure of memory accesses. In this contribution, we discuss how suited this massively parallel setup is for simulations of the multicanonical or Wang-Landau type, which have proven useful for the study of systems with complex energy landscapes and first-order phase transitions. In contrast to canonical simulations, such approaches appear to require knowledge of the current value of a global reaction coordinate such as energy or magnetization prior to each spin flip. This seems to preclude their efficient implementation on GPUs. We assess the performance potential of different parallel implementations of such algorithms on GPU and compare to the speedups previously gained for simulations in the canonical ensemble.

DY 40.40 Thu 17:00 P3

Quantum Criticality in the 3d Gross-Neveu Model from the Functional Renormalization Group — Jens Braun, Holger Gies, and •Daniel David Scherer — Theoretisch-Physikalisches Institut, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, D-07743 Jena, Germany

Using the functional renormalization group, we study the fixed-point structure of the three dimensional Gross-Neveu model describing planar Dirac fermions interacting in a scalar-scalar channel. We employ both a purely fermionic as well as a partially bosonized language. We find non-Gaußian fixed points responsible for gap generation by a second order quantum phase transition in both formulations, the universal critical exponents of which we determine quantitatively as a function of flavor number N_f. We also make contact to the large-N_f expansion. In this limit, the fixed-point action as well as all universal critical exponents can be computed analytically.

DY 40.41 Thu 17:00 P3

Cutting-Plane Approach for Vertex Covering of Random Graphs — •Timo Dewenter and Alexander K. Hartmann — Institut für Physik, Universität Oldenburg, 26111 Oldenburg

The NP-complete vertex cover problem (VC) on Erdős-Rényi (ER) random graphs with finite connectivity c is well studied [1]. Within numerical simulations, usually the minimum-size cover is calculated via branch-and-bound algorithms.

Here, we apply the translation of VC to a linear programming problem (LP), where the nodes of the graph are represented by variables $x_i \in [0, 1]$. Each edge $\{j, k\}$ of the graph corresponds to a constraint $x_j + x_k \geq 1$. The simplex algorithm is used to solve this LP, but for larger c less solutions of the desired form $x_i \in \{0, 1\}$ are found. So we use two heuristics to obtain better results. First, a node-heuristic is implemented, which generates an upper bound of the minimum cover. Further, a cutting plane approach is used, that adds constraints to the LP based on loops in the graph with odd length leading to exact solutions or lower bounds. We study the behaviour of these algorithms for ER random graphs as a function of c. After performing a statistical analysis [2] for different system sizes, we compare with the phase diagram for the critical fraction x_c of covered vertices.

[1] M. Weigth and A.K. Hartmann: *Number of Guards Needed by a Museum: A Phase Transition in Vertex Covering of Random Graphs*, Phys. Rev. Letters **84**, 26 (2000)
[2] A.K. Hartmann: *Practical Guide to Computer Simulations*, World-Scientific, 2009

DY 40.42 Thu 17:00 P3

Phasenübergänge zweidimensionaler Modellkolloide in äusseren periodischen Feldern — •Theda Brokamp und Peter Nielaba — Universität Konstanz, Deutschland

2D-Kolloide in eindimesional periodischen Feldern dienen als Modell für Phasenübergänge in zwei Dimensionen. Das eindimensionale Sinuspotential hat eine Wellenlänge, die $1/p$ der Braggebenen im Kolloidkristall entspricht (p=Kommensurabilitätsverhältnis). Hier werden erstmals Ergebnisse aus Monte Carlo Simulationen mit finite size scaling-Analysen gezeigt für Kommensurabilitätsverhältnisse $p = 3$ und $p = 4$. Dabei wurden Dichte und Potential variert. Die resultierenden Phasendiagramme zeigen modulated liquid, locked smectic und locked floating solid Phasen.