Diffusion of spheres through rod networks : the role of hydrodynamic screening

Tracer diffusion Fluorescence Correlation Spectroscopy experiments of a small sphere in a network of fd-virus rods are presented, both in the isotropic and nematic state, at different ionic strengths. In addition a theory will be discussed based on screened hydrodynamic interactions between the tracer sphere and the rod network. For a tracer sphere that is small in comparison to the meshsize of the network, hydrodynamic interactions determine to a large extent the long-time self diffusion coefficient. The hydrodynamic screening length of the rod network is obtained by comparing the experimental data with the theory. Surprisingly, the hydrodynamic screening length increases with increasing rod concentration in the nematic state.

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Particle dynamics in soft colloidal glasses under oscillatory shear

The technique of Dynamic Light Scattering Echo (DLS-echo) measures the time correlation function of the light scattered by a system subjected to an oscillatory shear. The intensity correlation function present peaks (echoes) which reflect the shear-induced rearrangements of the particles and provide information on the reversibility of these motions and thus on the yielding behavior of the sample. We have performed such experiments in glasses of hard and soft colloidal particles as a function of strain, frequency and volume fraction. We discuss the results obtained, correlate them with macroscopic rheological results and associate them with shear-induced microscopic rearrangements.

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Mode selection and stretching of capillary waves by shear flow

We discuss the flattening influence of shear flow on capillary waves in a phase separated colloid-polymer system. The roughness of the colloidal gas-liquid interface in equilibrium is analytically determined from a free energy, assuming a sharp density crossover. The resulting wavevectors k that contribute to the roughness are reconsidered in the case of shear flow on the basis of the decay time of the wave, determined by the linearised Navier-Stokes equation. Waves that are slow compared to the shear rate in the same direction, are excluded from the interfacial region, resulting in a lowering of the surface roughness. From the knowledge of the equilibrium roughness, the roughness and height-height correlation function of the interface under shear flow are predicted and compared to experimental data, showing at least qualitative agreement. Expressions for the macroscopic surface tension are used to give an estimation of the contribution of the capillary waves, as well as the lower cut-off of modes, above which the theory is assumed valid.

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Talk title: Mode selection and stretching of capillary waves by shear flow
Poster title: Mode selection and stretching of capillary waves by shear flow

On the limits of digital video microscopy

We explore the limits of digital video microscopy which is established as a standard method in physics, chemistry and biology. At particle distances close to contact we observe small but systematic deviations between the optically measured and the real particle distances. This difference is caused by the overlap of the optical images between neighboring particles. We present a new technique of particle detection which allows for correct measurements of particle distances.

CargeseTalk-024.data

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Talk title: On the limits of digital video microscopy

Numerical Studies of Ultrafine Particles in the Absence and Presence of External Fields

Length scales of particles and their surrounding medium strongly determines the nature of their interactions with one another and their responses to external fields. We are interested in systems of ultrafine particles (0.1 - 1.0 micron) such as solid aerosols, or fine powders, which are found in nature and industry. In nature, these systems are generated by volcanoes, dust storms or forest fires. In industry, they are found in pharmaceutical, cosmetic and food applications, apart from being generated by burning of fossil fuel in internal combustion engines. We develop a numerical model for these systems using the Derjaguin-Muller-Toporov (DMT) theory which considers both the van der Waals attraction between the particles and their contact mechanical interactions. We study the agglomeration dynamics of these systems in the absence and presence of gravity by controlling the surface properties of the particles. Finally, we explore the response of these systems to external fields by studying the evolution of the internal microstructure under contant load and shear strain. These inquiries can be used to determine bulk material parameters such as the shear modulus and the flowability.

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Talk title: Numerical Studies of Ultrafine Particles in the Absence and Presence of External Fields
Poster title: Ultrafine Particles: a numerical model and their behavior in the absence and presence of external fields

Spatial correlations and temporal heterogeneity of the slow dynamics of a colloidal fractal gel

We use a new method based on multispeckle dynamic light scattering to investigate the dynamics of a colloidal fractal gel. Our technique combines the recently introduced Time Resolved Correlation (TRC) and an imaging geometry to calculate intensity correlation functions that are resolved both in time and space (Space- and Time-Resolved Correlation, STRC). STRC measurements reveal that the dynamics of the gel are temporally heterogeneous. The instantaneous dynamics of distinct regions of the gel exhibit long-ranged spatial correlations, most likely due to the elastic propagation of rearrangement events along the gel network. Based on these observations, we propose that the temporal heterogeneity of the dynamics stems from the limited number of dynamically independent regions in the scattering volume, due to the extended spatial correlations, a behavior in striking analogy with recent theoretical and numerical work on glassy systems.

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Talk title: Spatial correlations and temporal heterogeneity of the slow dynamics of a colloidal fractal gel

Interfacial properties of a binary (point) Yukawa fluid

We investigate a simple model for binary mixtures of charged particles in a neutralising medium such as charged colloidal suspensions, dusty plasmas, and certain ionic mixtures, modelling the effective interactions via point Yukawa potentials. We use a simple parameterisation to mimic non-ideal charge renormalisation effects which can result in fluid-fluid separation, which is thought to occur in e.g. binary mixtures of H+ and He++ at astrophysical temperatures and pressures.

Using density functional theory we investigate the behaviour of the binary mixture at a planar wall and at the free interface between the two demixed fluid phases. A mean-field approximation for the Helmholtz free energy is used, which generates a simple analytical form for the pair direct correlation functions. For the simplest case of a hard-wall it is shown that there is a first order wetting transition, i.e. at total densities below the transition density, the phase rich in the more highly charged species completely wets the interface between the wall and the fluid phase rich in the less charged species. In this regime the film thickness diverges as l~-ln(x-x_coex) where (x-x_coex) is the deviation in concentration x of the more highly charged species from bulk coexistence. For total densities above the wetting transition no wetting film is present. Density profiles of the free interface between two co-existing states are also determined. These have a simple tanh(z) type form, i.e. without oscillations.

The transverse structure factor is introduced which describes density-density correlations between particles in the direction parallel to the free interface or the wall. For a typical hard-wall density profile with a thick wetting film it is shown that there are long ranged correlations between particles in the interface between the wetting film and the bulk fluid. These correlations exhibit typical Ornstein-Zernike behaviour, i.e. the amplitude of the correlations for all species decays with the transverse wave-vector, Q, as ~(1+zeta^2Q^2)^-1, where zeta is a transverse correlation length.

CargeseTalk-045.data

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Talk title: Interfacial properties of a binary (point) Yukawa fluid

Lane reduction in driven 2d-colloidal systems through microchannels

The transport behavior of a system of gravitationally driven colloidal particles is investigated. The particles form a two-dimensional system and are confined to narrow channels of various configurations. The interactions are determined by the superparamagnetic behavior of the particles. They can thus be arranged in a crystalline order by application of an external magnetic field. Therefore the motion of the particles through a narrow channel occurs in well-defined lanes. The arrangement of the particles is perturbed by diffusion and the motion induced by gravity. Due to these combined influences a density gradient forms along the direction of motion of the particles. A reconfiguration of the crystal is observed leading to a reduction of the number of lanes. In the course of the lane reduction transition a local melting of the quasi-crystalline phase to a disordered phase and a subsequent crystallization along the motion of the particles is observed. This transition is characterized using overdamped Brownian dynamics simulations and compared to experimental results. Additionally we study the influence of constrictions on the flow behavior.

[1] M. KÃ¶ppl, P. Henseler, A. Erbe, P. Nielaba and P. Leiderer, preprint arXiv.org/cond-mat/0606352

CargeseTalk-046.data

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The reversible freezing and melting of colloidal crystal

We report here the observation of the reversible fluid-solid phase transition in a dilute suspension of polystyrene in 3-methylpyridine (3MP)/H2O/D2O,as approaching the coexistence curve of binary ixture. The control parameter is the temperature.The strength and range of the interaction between the particles are tuned by the temperature. The formation of an FCC crystalline and glass phase depend on the quenching rate. The phase behaviors are characterized by the measurement of the structure factor S(q)with small angle X-ray scattering (SAXS). Real space imaging of the total sample and turbidity measurements complete the observation of the phase behavior

CargeseTalk-047.data

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Talk title: The reversible freezing and melting of colloidal crystal
Poster title: The reversible freezing and melting of colloidal crystal

Stacking disorder in hard sphere crystals

Authors:
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Perfect crystals hardly â€“ if ever â€“ occur in real life. In colloidal crystals so-called random stacking structure (rhcp) is frequently observed. In this contribution, we show that stacking disorder extends not only in orthogonal, but also in the lateral direction. Islands of A, B and C stacking occur within a single layer, and can persist in three dimensions. Laser scanning confocal microscopy is applied to sedimented crystals of fluorescently labeled poly-methyl-met-acrylate particles. We investigate both the effect of gravity and the effect of the flat bottom wall. Near the wall, more defects are initiated which we attribute to the lack of structure imposed by a layer below. The defects persist slightly less in microgravity, which is probably caused by a larger crystal equilibration time. Our datasets are sufficiently large to compare them to data obtained for crystals studied by small-angle x-ray diffraction, for which we find qualitative agreement.

CargeseTalk-050.data

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Talk title: Stacking disorder in hard sphere crystals
Poster title: Stacking disorder in hard sphere crystals

Effective temperature in stationary states of interacting Brownian particles under shear

We study fluctuation dissipation relations in stationary states of interacting Brownian particles under shear theoretically. In computer simulation studies of glassy states, the Fluctuation Dissipation Theorem (FDT) was found to be violated for particle motion in the vorticity direction, viz. perpendicular to the shear plane. At long times, an FDT with an effective temperature higher than the real one seems to hold.

We determine this effective temperature via the recently developed mode coupling approach for sheared colloidal dispersions, using the Smoluchowski equation to calculate time-dependent fluctuations and susceptibilities. The generalized FDT-relation between these susceptibilities and fluctuations for non-equilibrium stationary states is our exact starting point which we solve by mode coupling approximations and further simplification to a schematic model. We focus on the diffusion of a tagged particle in the vorticity direction.

CargeseTalk-053.data

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Talk title: Effective temperature in stationary states of interacting Brownian particles under shear

Measurement of interparticle potential in liquid crystal using magneto-optical tweezers

We used magneto-optic tweezers for measurements of liquid crystal mediated forces between microscopic beads in thin nematic samples. The main advantage of this method over optical tweezers is the low intensity of the external field used in the experiment. The magnetic field (below 10 mT) is too low to reorient the director, whereas the electric field of the trapping laser beam alters the nematic director configuration around a trapped bead [1]. We measured the force-separation dependence of the repulsive force as well as the velocity with which the particles are pushed apart by the liquid crystal [2]. The ratio yields the effective drag coefficient, which we find independent of bead separation for separations as small as 1.1-times the bead diameter.

[1] I. Musevic, M. Skarabot, D. Babic, N. Osterman, I. Poberaj, V. Nazarenko, A. Nych, Phys. Rev. Lett., 93, 187801 (2004).

[2] J. Kotar, M. Vilfan, N. Osterman, D. Babic, M. Copic, I. Poberaj, Phys. Rev. Lett., 96, 207801 (2006)

CargeseTalk-054.data

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Talk title: Measurement of interparticle potential in liquid crystal using magneto-optical tweezers
Poster title: Measurement of interparticle potential in liquid crystal using magneto-optical tweezers

ï»¿Micro- and nano- colloids in a capillary filled with a nematic liquid crystal

Experimental and theoretical study on the ordering of micron and nano-sized colloids in a supramicrometer capillary filled with a nematic liquid crystal will be presented. With larger micron-sized colloids formation of chains is observed, which surprisingly branch in the direction perpendicular to the capillary axis. Behavior of smaller nano-sized colloids however proves to be different, since colloids either buckle together into larger Â»dropletsÂ« or form chains with various conformations.

CargeseTalk-056.data

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Talk title: Micro- and nano- colloids in a capillary filled with a nematic liquid crystal
Poster title: Micro- and nano- colloids in a capillary filled with a nematic liquid crystal

The hexatic phase in a 2d colloidal system

The theory of two-dimensional melting, developed by Kosterlitz, Thouless, Halperin, Nelson and Young (KTHNY-theory) has been a matter of debate over decades. Previously we demonstrated the oftening of a crystal due to the appearance of dislocations close to the crystal $\rightarrow$ hexatic phase transition. Here we focus on the breaking of the orientational symmetry at the hexatic $\rightarrow$ isotropic liquid transition. Using positional data from video-microscopy of a colloidal system we calculate the bond-order correlation function G_6. We verify qantitatively that the decay of G_6 switches from algebraic to exponential during melting at the hexatic-liquid transition. For the hexatic phase the temperature dependent exponent η of the algebraic decay is extracted and analyzed. It is related to the modulus of rotational stiffness, Frank's constant F_A. Indeed, F_A becomes $2/\pi$ at the hexatic $\rightarrow$ isotropic liquid phase transition as predicted by KTHNY-Theory. This is a quantitative test for the mechanism of breaking the orientational symmetry.

CargeseTalk-062.data

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Poster title: The hexatic phase in a 2d colloidal system

CargeseTalk-065.doc

Creating templates for nucleation and growth of colloidal (photonic) crystals

E.C.M. Vermolen, A.I. Campbell, A. van der Horst, M. Leunissen, D.L.J. Vossen and A. van Blaaderen

We present easy-to-use and inexpensive techniques to make templates for colloidal epitaxy to grow photonic crystals. Optical tweezers are used to trap and move colloidal particles in a suspension and position them on a surface with nanometer precision, to generate templates [1]. These templates made with optical tweezers and templates made with e-beam-lithography, are used for epitaxial colloidal crystal growth [2] of metastable photonic crystals. We are currently trying to grow colloidal quasi-crystals and Laves structi t2 5sying hep

Non Equilibrium Crystalline and Amorphous states of a Driven Solid.

We show that a collection of particles in two dimensions, interacting by an inter-atomic potential consisting of two and three body terms which supports both triangular and square crystalline states, undergoes a series of transitions when driven over a quenched random external potential [1]. Starting from a pinned square lattice, an increase of the driving force, de-pins the solid at the same time melting it. At higher values of the force, the melt crystallizes into a triangular solid, which undergoes a kinetic structural transition back to the square lattice at yet higher values of the force. We obtain the full dynamical phase diagram of the system for a range of values of the force and the strength of the three body interactions. During the structural transitions we monitor sharp changes in several quantities like transverse velocity and distribution functions for various structural and kinetic parameters. We propose to understand this phase transition in terms of a "shaking temperature" [3].

[1] A. Sengupta,S. Sengupta,G. I. Menon, Europhys. Lett. 70 (5), pp. 635-641 (2005).

[3] A.E.Koshelev,V.M.Vinokur, Phys.Rev. Lett. 73, 3580 (1994).

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Poster title: Non Equilibrium Crystalline and Amorphous states of a Driven Solid.

CargeseTalk-072.doc

A numerical study of the liquid-solid nucleation in oppositely charged colloids

Nucleation is an activated process: it occurs rarely and, when it happens, it proceeds very fast. This is why computer simulation is an excellent tool to understand the nucleation phenomena. Moreover, it allows a detailed microscopical analysis of the nucleation pathways.
In this work we study the transition from a metastable liquid to a stable solid in a system formed by oppositely charged colloids of equal size.
The interaction between colloids -screened coulombic- is modelled with a Yukawa potential. We analyze the first steps of the phase transition at different thermodynamical conditions. Using especial simulation techniques we are able to study the mechanism of the transition and to compute the nucleation rate.

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CargeseTalk-074.doc

Freezing of Superparamagnetic Colloids in Two Dimensions

We show that the Modified Weighted Density Approximation (MWDA) to the Density Functional Theory (DFT) correctly predicts freezing of superparamagnetic spheres in 2D which are subject to a constant external magnetic field directed perpendicular to the 2D--plane. The incorporation of three--particle correlations is crucial in order to obtain a freezing temperature reasonably close to the transition temperature found in experiment. With the help of Dynamical Density Functional we further study the crystallization dynamics of the system under consideration.

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Random field effects in colloidal fluids with quenched disorder

In this talk, I will demonstrate that colloid-polymer mixtures inside quenched random matrices show critical behavior different from the ordinary 3D Ising universality class. Rather, the critical behavior seems to be that of the random field Ising model.

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