CPP 20: Poster: Colloids and Complex Liquids

Time: Tuesday 18:15–20:15 — Location: Poster C

CPP 20.1 Tue 18:15 Poster C
Many-body effects for critical Casimir forces — •Thiago Mattos[1,2], Ludger Harnau[1,2], and Sigfried Dietrich[1,2] — [1]Max Planck Institute for Intelligent Systems, Stuttgart, Germany — [2]IV. Institute for Theoretical Physics, Stuttgart University, Stuttgart, Germany

Within mean-field theory we calculate the scaling functions associated with critical Casimir forces for a system consisting of two spherical colloids immersed in a binary liquid mixture near its consolute point and facing a planar, homogeneous substrate. For several geometrical arrangements and boundary conditions we analyze the normal and the lateral critical Casimir forces acting on one of the two colloids. We find interesting features such as a change of sign of these forces upon varying either the position of one of the colloids or the temperature. By subtracting the pairwise forces from the total force we are able to determine the many-body forces acting on one of the colloids. We have found that the many-body contribution to the total critical Casimir force is more pronounced for small colloid-colloid and colloid-substrate distances, as well as for temperatures close to criticality, where the many-body contribution to the total force can reach up to 25%.

CPP 20.2 Tue 18:15 Poster C
Viscosity of polyelectrolyte solutions and nanoparticle suspensions measured by AFM cantilevers — •Cagri Üzüm, Alexandra Abraham, Howard Setyamukti, and Regine von Klitzing — Stranski-Laboratorium, Institut für Chemie, TU Berlin, Strasse des 17.Juni 124, 10623 Berlin, Germany

Density and viscosity of fluids can be determined locally i.e. in micro-scale using the frequency response of atomic force microscopy (AFM) cantilevers [1]. This contribution aims to measure the viscosity of polyelectrolyte solutions and nanoparticle suspensions at interfaces and at various volume scales. The interfacial viscosity can be manipulated by modifying the surface of the AFM cantilever (charge, hydrophobicity, etc.). The volume of interest can be controlled by tuning the resonance amplitude of the cantilevers via magnetic excitation [2]. In general, the viscosity of flexible polyelectrolyte (NaPSS, PAMPS) or small (9nm) particle systems measured by AFM increases with resonance amplitude and approaches the bulk viscosity. On the contrary, rigid polyelectrolyte (DNA, Chitin) or larger particle (26nm) systems have a significantly reduced micro-scale viscosity as compared to bulk. The entropic and kinetic sources of this difference will be addressed.
[1] Boskovic, S. et al. J. Rheol., 2002, 46, 891-899
[2] McLoughlin, N. et al. Appl. Phys. Lett., 2006, 89

CPP 20.3 Tue 18:15 Poster C
Dielectric spectroscopy of spherical Water/AOT/Decane microemulsions in the GHz regime — •Björn Kuttich, Robert Wipf, and Bernd Stühn — Experimental Condensed Matter Physics, TU Darmstadt, Germany

Microemulsions are widely used ternary mixtures in industrial as well as fundamental research. Besides structural properties like the temperature depending shape and size of the microstructure, the dynamics of the microemulsions, especially in the spherical phase are of great interest. Focusing on spherical microemulsions in particular it is possible to change the properties of the existing surfactant shell by adding e.g. polymers either to the core or the matrix phase of the system. Investigating such polymer loaded spherical microemulsions slid into focus of recent research because they can be considered a model systems for the interaction between proteins and cell membranes.

Broadband dielectric spectroscopy is a commonly used method to investigate the dynamics of microemulsions. Using AOT based water in oil microemulsions it is possible to observe in addition to an enormous temperature dependency of the conductivity due to dynamic percolation also dielectric relaxations. The shell relaxation resulting from ion reorganisation in the surfactant shell evolves to the so called cluster relaxation while approaching the percolation temperature, which in turn can be influenced by adding different polymers. Following this relaxation up to the GHz regime allows now to investigate closer the formation of clusters during the percolation process.

CPP 20.4 Tue 18:15 Poster C

CPP 20.4 Tue 18:15 Poster C
Temperature dependent behaviour of droplet and droplet shell in decan/AOT/H_2O microemulsions — •Markus Domschke, Sabine Best, and Rudolf Feile — TU Darmstadt, Institut für Festkörperphysik, Hochschulstraße 8, 64289 Darmstadt,Germany

The behaviour of water/AOT/decan microemulsions in the droplet phase of different sizes ($\omega = 2 - 40$) and droplet volume fractions of $\phi = 0.1 - 0.4$ is studied in a wide temperature range.

Combining differential scanning calorimetry (DSC) and refractive index measurements induce a new perspective of AOT-bound water in the droplets [1]. Small angle X-Ray scattering (SAXS) allows continuous analysis of the droplet structure between supercooling temperature of bulk water and phase separation temperature within a unique model. We introduce a combined structure factor of hard spheres [2] and *Ornstein-Zernicke* type [3].
[1] M. van Dijk *et al.*, J. Phys. Chem. **93**, 2506 (1989)
[2] N. W. Ashcroft and J. Lekner, Phys. Rev. **145**, 83 (1966)
[3] M. Kotlarchyk *et al.* , Phys. Rev. A **28**, 508- (1983)

CPP 20.5 Tue 18:15 Poster C
Vibrational density of states and molecular dynamics of discotic liquid crystals in the bulk and in the nanoconfined state investigated by neutron scattering — •Christina Krause[1], Bernhard Frick[2], Reiner Zorn[3], and Andreas Schönhals[1] — [1]BAM Federal Institute for Materials Research and Testing, Unter den Eichen 87, 12205 Berlin, Germany — [2]Institut Laue Langevin, 6, rue Jules Horowitz, B.P. 156, F-38042 Grenoble Cedex 9, France — [3]Juelich Centre for Neutron Science, Forschungszentrum Juelich, 52425 Juelich, Germany

Discotic liquid crystals (DLC) consist of a flat and rigid aromatic core substituted by flexible aliphatic chains. While the former is responsible for the pi-stacking, the latter increases the solubility and gives rise to a rich thermotropic behavior. DLCs are self-assembled materials. The disc-shaped molecules organize into columns that further assemble into two-dimensional arrays with a hexagonal mesophase. The alkyl chains fill the intercolumnar space giving rise to a nanophase separated state. Two triphenylene derivatives as model systems for DLCs were investigated by neutron scattering in the bulk and confined in nanometre wide channels of anodic alumina membranes. The vibrational density of states as well as the molecular dynamics on a time scale of ca. 1 ns (elastic scans) were considered. The influence of both the molecular structure (length of the aliphatic chains) and the confinement will be discussed in detail.

CPP 20.6 Tue 18:15 Poster C
Micro-fabricated ionic liquid colloid emitter based on SU-8 capillaries with electroplated front electrodes — •Katharina Huhn, Markus Piechotka, Torsten Henning, and Peter J. Klar — Justus-Liebig-Universität, I. Physikalisches Institut, Heinrich-Buff-Ring 16, 35392 Gießen, Germany

We manufactured a colloid emitter device using the negative resist SU-8 with multiple step photolithography. In the first step thin capillaries were manufactured with an inner diameter varying between 10 to 100 microns whilst the height is about 40 microns. In the second step a spacer layer was patterned. A metal grid structure was deposited onto the top of the surface of the spacer layer using evaporation, electroplating as well as ion beam etching. Afterwards the substrate was removed by wet chemical etching. For testing the device was bonded on a tank filled with an ionic liquid. An electric field was applied between the ionic liquid and the extraction electrode by using a high voltage source. The electro-spray emission was observated via videoscopy. We investigated the influence of different ionic liquids and capillary diameters on the required extraction voltage.

CPP 20.7 Tue 18:15 Poster C
Pressure calculation for polydisperse magnetic fluids — •Elena Minina[1,2], Ekaterina Novak[1], and Sofia Kantorovich[1,3] — [1]Ural Federal University, Lenin av. 51, Ekaterinburg,620000, Russia — [2]Institute for Computational Physics, University of Stuttgart, Allmandring 3, 70569, Stuttgart, Germany — [3]Sapienza University of Rome, Piazzale A. Moro 5, 00185, Rome, Italy

Magnetic fluids (the systems of magnetic dipolar particles suspended in nonmagnetic liquids) possess a wide range of physical properties

which are currently under study. Typically, the synthesis of industrial magnetic fluids leads to a broad particle size distribution or so-called polydispersity of the system. Even in the absence of an external magnetic field the polydispersity plays a crucial role in cluster formation and significantly changes the microstructure of magnetic fluids what is confirmed by the work [C. Holm at al, J. Phys.: Cond. Mat. 18 (2006)]. In the present study we would like to elucidate how polydispersity influences one of the experimentally measurable macroscopic properties such as pressure of the system. We consider bidisperse system of magnetic dipolar soft or hard particles as the simplest case of polydisperse magnetic fluid. For such system we perform theoretical calculation of pressure using method of diagram expansion that is in a good agreement with data obtained via by molecular dynamics simulations in ESPResSo. The final analysis of pressure for bidisperse system confirms that the pressure is very sensitive to the polidispersity of the system.

CPP 20.8   Tue 18:15   Poster C
The Effect of Different Polymer Length on Water Droplets of Reverse AOT microemulsion — •Masoud Amirkhani[1], Soheil Sharifi[1], Sérgio Funari[2], and Othmar Marti[1] — [1]Institut für Experimentelle Physik, Universität Ulm, Albert-Einstein-Allee 11 89081 Ulm — [2]HASYLAB, Notkestrasse 85, D-22607 Hamburg, Germany

We study the effect of polyethylene glycol (PEG) on the dynamic and structure of the reverse AOT microemulsion. The mixture of water and oil with anionic surfactant AOT (sodium bis-(2-ethylhexyl) sulfosuccinate) can form microemulsion. The dynamic of microemulsion in the presence of PEG is investigated by photon correlation spectroscopy technique. We mainly focus on the variation of the translational diffusion behavior as a function of the polymer concentration and polymer length scale. By increasing the content of the lowest PEG length scale (Mn=285) the dynamic of microemulsion slows down. In addition, one relaxation process is distinguished for all polymer concentration. However, for the two higher polymer length scale (Mn=2200 and 6000) two relaxations are observed and the dynamic of microemulsion speed up. We used the small angle X-ray scattering technique to monitor the size and the polydispersity of the mixture system (AOT-microemulsion/PEG).

CPP 20.9   Tue 18:15   Poster C
A multicolor interferometer for the simultaneous measurement of contrast factors — •Thomas Triller and Werner Köhler — Physikalisches Institut, Universität Bayreuth, 95440 Bayreuth, Germany

During the last years thermodiffusion in ternary fluid mixtures has been the subject of gaining interest. Currently, optical experiments are performed both in a microgravity environment on board of the international space station (ISS) using an interferometric device (SODI) and on ground using the beamdeflection technique [1]. These experiments make use of a change in the refractive index n to analyse changes in the concentration of the mixtures. To interpret the data, a precise knowledge of the so called contrast factors $(\partial n/\partial c_i)_{p,T,c_{j\neq i}}$ and $(\partial n/\partial T)_{p,c_i}$ is essential. Monte Carlo simulations have shown that errors in the refractive index need to be as low as 10^{-5} to get reliable values for the Soret coefficients. As a step to reach such precision, we present a new setup capable of measuring contrast factors at five different wavelengths simultaneously. The basic outline consists of a Michelson-Interferometer with a special sample cell.

[1] Königer, A., Wunderlich, H. and Köhler, W., *J. Chem. Phys*, **132**, pp. 174506, 2010.

CPP 20.10   Tue 18:15   Poster C
Self assembly in a two-dimensional system of hard disks with quadrupolar interaction — •Malte Kähne and Sabine H. L. Klapp — Institut für Theoretische Physik, TU Berlin, Hardenbergstraße 36, D-10623 Berlin, Germany

Using standard Monte Carlo algorithms in the grand canonical ensemble, we examine the thermodynamic properties and the structural behaviour of a two-dimensional hard disk fluid with quadrupolar interaction potential. At low temperatures, this liquid exhibits a cluster phase. We locate this cluster phase and study the aggregation of these clusters as well as their size distribution. We analyse the structure of these clusters by local bond-angle order parameters and the pair correlation function. Our results illustrate the likelihood of the T-structure, which is also found as a stable crystal structure for three-dimensional quadrupolar fluids [1].

[1] C. Vega, B. Garzon, S. Lago and P. A. Monson, J. Mol. Liq 73, 157 (1998)

CPP 20.11   Tue 18:15   Poster C
Network formation in polydisperse colloidal systems induced by an uni-axial external field — Heiko Schmidle, Sebastian Jäger, •Florian Kogler, and Sabine H.L. Klapp — Institut für Theoretische Physik, TU Berlin, Hardenbergstr. 36, D-10632 Berlin, Germany

Using Molecular Dynamics and Monte Carlo simulations we investigate a theoretical model of two-dimensional colloids with one or two (anti-parallel orientated) induced dipole moments mimicking recent experiments on mixtures of polysterene colloids with and without gold patches in the presence of an external electric field [1]. Such systems percolate in field direction and perpendicular to it. We are able to determine percolation transitions for both cases and identify basic connection types of different colloids [2]. Furthermore the percolated model system shows strongly hindered translational dynamics indicating gelation.

[1] S. Gangwa, A. Pawar, I. Kretzschmarb and O. D. Velev, Soft Matter, 6:1413-1418 (2010)
[2] H. Schmidle, S. Jäger, C. K. Hall, O. D. Velev, and S. H. L. Klapp, Two-dimensional colloidal networks induced by a uni-axial external field, submitted (2012)

CPP 20.12   Tue 18:15   Poster C
Magnetic Field Controlled Composite Paramagnetic-Diamagnetic Colloidal Phases — •Fabian Wagle, Ayan Ray, and Thomas Fischer — EPV, Uni Bayreuth

We report on differently ordered colloidal phases of a mixture of paramagnetic and diamagnetic colloids subject to a quickly varying time dependent magnetic field. Effectively paramagnetic and effectively diamagnetic colloids are created from paramagnetic and nonmagnetic colloids immersed into a thin film of aqueous ferrofluid. The time-averaged dipole interaction between induced dipoles can be characterized by a uniaxial external precession angle and a biaxial eccentricity characterizing the anisotropy of the external field modulation. The variation of both control parameters causes a sequence of transitions between differently correlated orientation order between the paramagnetic and diamagnetic colloids. We observe the formation of bonds between paramagnets and diamagnets along one or two directions with a staggered order of the magnetic moments. Bonds between similar particles with uniform order of the magnetic moments form along directions orthogonal to bonds between different particles along the staggered directions. When the external precession angle passes the magic angle, the particle order rearranges and staggered directions with bonds between different particles change into uniformly ordered directions with bonds between similar particles and vice versa. The transition in order occurs in two steps with a biaxial phase intervening between the two uniaxial ordering phases.

CPP 20.13   Tue 18:15   Poster C
Noninvasive measurement of dissipation in colloidal systems — •Jakob Mehl[1], Boris Lander[2], Udo Seifert[2], and Clemens Bechinger[1,3] — [1]2. Physikalisches Institut, Universität Stuttgart, Germany — [2]II. Institut für Theoretische Physik, Universität Stuttgart, Germany — [3]Max-Planck-Institute for Intelligent Systems, Stuttgart, Germany

According to Harada and Sasa [Phys. Rev. Lett. 95, 130602 (2005)], heat production generated in a nonequilibrium steady state can be inferred from measuring response and correlation functions. In many colloidal systems, however, it is a nontrivial task to determine response functions, whereas details about spatial steady state trajectories are easily accessible. Using a simple conditional averaging procedure, we show how this fact can be exploited to reliably evaluate average heat production. By combining paramagnetic colloidal particles, rotating laser tweezers and digital video microscopy, we apply the new method to two nonequilibrium steady states, which can be coupled by an externally controlled magnetic field. We show, that the average heat production is nonmonotonic in the coupling strength and even for low statistics quite robust results are available [Phys. Rev. E. 86, 030401(R) (2012)].

CPP 20.14   Tue 18:15   Poster C
Structure of confined microemulsions in AAO nanopores — •Frederik Lipfert and Henrich Frielinghaus — Jülich Centre for Neutron Science, Forschungszentrum Jülich GmbH, 85747 Garching

Microemulsions are used in a variety of different applications such as detergence or oil recovery where they are exposed to a variety of surfaces and confinements. We analyzed the structure of symmetrical microemulsions with different surfactant concentrations in two-dimensional confinement using cylindrical nano pores arranged hexagonally on anodized aluminum oxide (AAO) membranes. The microemulsions we used have a water-oil domain sizes in the range of 200Å while the pores we used have diameters of 180nm and 400nm. We found the microemulsion exhibiting a lamellar, shell-like structure at the interface even tough their equilibrium state is bicontinuous. We used small angle neutron scattering for the analysis because of the neutron wavelength being comparable to the examined structures and the possibility of contrast matching the microemulsion to the AAO membranes by partly replacing the H2O with D2O. This matching suppresses the scattering from the membrane which would overshadow the scattering from the microemulsion and makes the microemulsion scattering accessible. The scattering from the interface near lamellar structure is Bragg like while the scattering from the bicontinuous microemulsion in the pore center is isotropic. Both structures have the same domain size so in order to distinguish between both structures we set up the sample perpendicular to the incoming neutron beam then turned it 15° making the scattering from the lamellar structure visible.

CPP 20.15   Tue 18:15   Poster C
Directional locking and dynamical ordering of fluid colloidal monolayers driven across quasiperiodic substrate potentials — •Thomas Bohlein, Christoph July, and Clemens Bechinger — 2. Physikalisches Institut, Universität Stuttgart, Germany

Particles driven across an ordered potential energy surface may either follow the direction of the driving force or become entrained along any of the commensurate directions of the substrate. Such directional locking effects are of great technological relevance since they allow sorting of particles according to their size or refractive index. Here we experimentally study the sliding behavior of a two dimensional disordered colloidal monolayer interacting with quasiperiodic light induced substrate potentials. When the direction of the driving is varied with respect to the substrate, we find directional locking at angles corresponding to the symmetry axes of the underlying potential. On the locking steps the colloids assemble into dynamically ordered structures which consist of periodically spaced bands. We show that such ordered colloidal phases can be understood within the framework of periodic average structures which stems from the structure determination of complex metal alloys.

CPP 20.16   Tue 18:15   Poster C
Fundamental mixed measure theory for fluids of hard particles — •René Wittmann and Klaus Mecke — Institut für Theoretische Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg, Staudtstraße 7, 91058 Erlangen, Germany

A density functional for anisotropic hard bodies can be constructed in terms of weighted densities which depend on geometry and position of only one single oriented particle [1]. We study the liquid crystalline behavior of a system of hard spherocylinders and compare the results to Monte-Carlo simulations.

The density profile and the director dependence at the isotropic-nematic interface show the correct behavior. The functional also provides closed formulas for the Frank elastic coefficients via the Poniewierski-Stecki equations. The original fundamental measure theory is improved by eliminating the divergence in the free energy of the otherwise unstable smectic phase.

We propose a new geometric method to derive the low-density limit of the exact density functional. Here, so-called mixed measures of two bodies are used rather than weighted densities of only one single particle. This might evade present approximations and lead to an improved density functional for liquid crystals.

[1] H. Hansen-Goos and K. Mecke, Phys. Rev. Lett. **102**, 018302 (2009).

CPP 20.17   Tue 18:15   Poster C
Measuring thermal diffusion of binary mixtures using a two color optical beam deflection technique — •Matthias Gebhardt and Werner Köhler — Physikalisches Institut, Universität Bayreuth, D-95440 Bayreuth, Germany

We have measured and analyzed in detail the Soret, diffusion and thermal diffusion coefficients of the binary mixtures of dodecane, isobutylbenzene and 1,2,3,4-tetrahydronaphthalene, the benchmark systems that are currently also investigated on board the International Space Station ISS in the DCMIX program, at various concentrations. The measurements were performed using a two color optical beam deflection technique, which is equipped with two laser diodes one at 405nm and the other at 635nm. With these two wavelengths we can measure one sample and receive simultaneously two deflection signals. The two signals can be used independently to evaluate the transport coefficients in order to verify the results. The measured beam deflection signal is strongly determined by the so called contrast factors. These contrast factors are the derivatives of the refractive index with respect to concentration and temperature, which have to be determined with high accuracy. We use the Lorentz-Lorenz equation and also the modified equation by Looyenga, to calculate the contrast factors using the refractive index, density and molecular polarizability, as described by Li et al [1]. In order to obtain a quantitative agreement with the experimental data, it is necessary to take the temperature dependence of the molecular polarizabilities into account.

[1] W. B. Li et al., The Journal of Chemical Physics 101, 5058 (1994)

CPP 20.18   Tue 18:15   Poster C
Particle dynamics in dense suspensions flowing through microchannels — •Michel Duits — MESA+ Institute, University of Twente, PO Box 217, 7500 AE Enschede, The Netherlands

We will report on a systematic study, aimed at understanding the dynamics of colloidal hard spheres inside microfluidic channels. Real-time confocal microscopy is used to visualize the structure, diffusion and flow of model suspensions of 1 micron diameter silica spheres. By controlling the flow speed, we cover a range of Peclet numbers ($<<1$ and $>>1$) so we can study both the diffusion-controlled and the flow-controlled dynamics. Analysis of the apparent diffusion coefficient in the direction perpendicular to the flow reveals a clear spatial dependence of the diffusivity on the distance to the wall(s). While this is found both at low and at high Peclet numbers, the manifestations and underlying mechanisms are very different.

CPP 20.19   Tue 18:15   Poster C
Influence of molecular structure on rheological properties of hydrogen bonded supramolecular polymeric melts — •Tingzi Yan[1], Klaus Schröter[1], Florian Herbst[2], Wolfgang Binder[2], and Thomas Thurn-Albrecht[1] — [1]Institute of Physics, Martin-Luther University Halle-Wittenberg, Halle 06120, Germany, — [2]Institute of Chemistry, Martin-Luther University Halle-Wittenberg, Halle 06120, Germany,

Combining SAXS and rheology the relation between self-assembly and mechanical properties has been studied. A semi-quantitative understanding of the influence of structure on the rheological properties in the bulk state has been achieved. Three polyisobutylene samples with thymine/2,6-diaminotriazine functional end groups were used as model system. Two different solidification scenarios were observed. In one case ordering of micelles at lower temperatures can be observed. In the second case the formation of disordered hydrogen bonded network leads to gelation at lower temperatures.

CPP 20.20   Tue 18:15   Poster C
Friction of colloidal monolayers on a periodic substrate — •Christoph July, Thomas Bohlein, and Clemens Bechinger — 2. physikalisches Institut, Universität Stuttgart

Friction is an ubiquitous and fundamental phenomenon in our every day life. While its precise control is highly desirable for technical applications, a comprehensive understanding of friction is still lacking. On the macroscopic level asperities mediate a partial contact between two surfaces leading to the well known static and dynamic friction. However, many interesting friction effects only happen on an atomic scale. Friction phenomena of sliding atomic monolayers in this regime are theoretically described by the Frenkel-Kontrova model. One particular effect, that is predicted by this theory, is the so called Aubry-Transition. This transition gives rise to a jump from static friction to a superlubric state (frictionless) between two incommensurate monolayers as the interaction between the atoms of a single monolayer grows in strength and exceeds a critical value. Yet systems of nano meter size are very hard to observe experimentally. To overcome this difficulty we devised a colloidal model system to emulate the nanoscopic world, enabling us to measure nano tribologic effects with microscopic particles. For this purpose we employ para-magnetic particles, which allow us to tune the particle-particle interaction by applying an external magnetic field. Monolayers of these particles are situated on a potential landscape generated by a light field and pulled across this

periodic substrate. In doing so, we are able to directly observe the Aubry transition for the first time.

CPP 20.21 Tue 18:15 Poster C
Gradient diffusion in mono- and bidisperse magnetic fluids —
•Alla Muratova[1], Alexey Ivanov[1], and Sofia Kantorovich[1,2] — [1]Ural Federal University, Lenin av. 51, 620000, Ekaterinburg, Russia — [2]Sapienza, University of Rome, Piazza A. Moro 5, 00185, Rome, Italy

We present the results on the mobility and diffusion coefficients in the systems of magnetic dipolar particles. In our study we firstly investigate the influence of chain formation and polydispersity of particles on self-diffusion. Here, we use Density Functional Approach and direct calculations to elucidate why the formation of chains leads to the average decrease of mobility in monodisperse systems, but in the case of a bidisperse particle size distribution the particle mobility becomes a function of the fractional composition. As the second step we calculate the diffusion coefficients using the mobility coefficients obtained before for both mono- and bidisperse systems of magnetic particles. Here, we mainly focus on the diffusion induced by the gradient of the total ferroparticle density. Finally, we use the diffusion coefficients to calculate the distribution of chains in the gravity gradient. We extensively compare our results to the simulation data and find them in a good agreement.

CPP 20.22 Tue 18:15 Poster C
Synthesis of Hematite particles monitored using in-situ SAXS and WAXS — •Alexander Schavkan, Fabian Westermeier, Ingo Steinke, Jan Perlich, Birgit Fischer, Gerhard Grübel, and Michael Sprung — DESY Deutsches Elektronen-Synchrotron, Notkestraße 8, 22607 Hamburg, Deutschland

To study the statistical physics of phase transitions, colloidal suspensions are often used as model systems. Due to their complex phase diagrams, suspensions of anisotropic nanoparticles, like hematite particles, are particularly interesting. These particles can be synthesized with varying size aspect ratios and can be aligned in an external magnetic field. The described experiments aimed to investigate the evolution of the synthesis and the appearance and growth of the magnetic moment during the chemical reaction.

Two syntheses were performed under an applied static magnetic field and monitored using in-situ SAXS and WAXS. While in one of these syntheses the growth of anisotropic, spindle shaped particles was induced by the addition of NaH_2PO_4, the second chemical reaction yielded isotropic, cubic shaped particles. By SAXS measurements the appearance of a magnetic moment in the particles and the development of the particle size and size distribution was investigated. WAXS experiment monitored the change in the chemical composition of the particles from Iron(III)chloride to hematite (β-Iron(III)oxide).

This contribution shows the details and the results of the experiment.

CPP 20.23 Tue 18:15 Poster C
Interactions of colloids and DNA with confining charged nano-channels: Analysis of numerical solutions of the Poisson-Boltzmann equation and molecular dynamics simulations. — •Dmitry Rozhkov[1], Alexander Schlaich[2], Sofia Kantorovich[1,3], and Marcello Sega[4] — [1]Ural Federal University, Lenin av. 51, 620000, Ekaterinburg, Russia — [2]Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, D-14195 Berlin — [3]Sapienza, University of Rome, Piazza A. Moro 5, 00185, Rome, Italy — [4]Tor Vergata University of Rome, via della Ricerca scientifica 1, I-00133 Rome, Italy

Nanoscopic confinement of ionic solutions is often met in both biological systems and technical applications but the computation of electrostatic interactions in electrolyte solutions is still challenging. The Poisson-Boltzmann equation can be used for the simple case of monovalent ions. The numerical solution usually implies that the boundary conditions are known a priori, but in strongly confined systems such as charged nano-channels or for strongly overlapping Debye-layers the usual assumptions of constant potential or constant flux boundary conditions break down. Molecular dynamics simulations proved to be an efficient tool to analyse systems with dielectric mismatch. However, realistic salt concentrations and confinements are rarely feasible in simulations. We use both a numerical Poisson-Boltzmann scheme and molecular dynamics simulations for calculating the effects of colloidal particles and DNA in confinement in order to elucidate the effect observed by Krishnan et al [Nano Lett., 7, 1270 (2007)].

CPP 20.24 Tue 18:15 Poster C
Controlling the cross-linker distribution and shell thickness of gold-poly-NIPAM core-shell colloids — •Matthias Karg[1], Paul Mulvaney[2], Sabine Rosenfeldt[3], and Sarah Jaber[2] — [1]Universität Bayreuth, Physikalische Chemie - Kolloidale Systeme — [2]University of Melbourne, School of Chemistry & Bio21 Institute — [3]Universität Bayreuth, Physikalische Chemie I

The encapsulation of inorganic nanoparticles with responsive polymer networks has attracted significant interest in recent years, since such materials can combine properties of their different components. Most effort so far was devoted to the encapsulation of different inorganic cores such as silica, gold and silver nanoparticles. It has been demonstrated that cores with a broad range of sizes can be used to build up such core-shell colloids. The present contribution focuses on the control of the polymer network structure rather than on the nanoparticle core. We encapsulated 15 nm gold nanoparticles into thermoresponsive polymer shells composed of NIPAM with a constant feeding of the cross-linker BIS during the polymerization. This leads to core-shell colloids with single nanoparticle cores well encapsulated in homogenously cross-linked poly-NIPAM shells. Additional polymerization steps can be used to overgrow the shells still keeping the cross-linker distribution homogeneous. Analysis using TEM, AFM and UV-Vis-spectroscopy will be presented. The shell morphology was investigated with SANS. An Ornstein-Zernicke analysis of the scattering profiles clearly reveals a homogenous network structure with correlation lengths of approx. 1.5 nm.

CPP 20.25 Tue 18:15 Poster C
Sedimentation and orientational order of active bottom-heavy particles — •Katrin Wolff, Marc Hennes, and Holger Stark — Institut für Theoretische Physik, Technische Universität Berlin

Self-propelled particles in an external gravitational field have been shown to display both an increased sedimentation length and polar order even without particle interactions [1,2]. Here, we investigate self-propelled particles which additionally are bottom-heavy, that is they feel a torque aligning them to swim against the gravitational field. We study their dynamics in an external gravitational field analytically and numerically using Brownian dynamics simulations. For bottom-heavy particles the gravitational field has the two opposite effects of i) sedimentation and ii) upward alignment of the particles' swimming direction. Depending on the strength of gravity, the particles' swimming speed and the aligning torque, we observe either effective sedimentation with increased sedimentation length (compared with the passive case but also the active case without bottom-heaviness) or inversion where particles swim towards the top of the box. We will give analytical results for sedimentation lengths and polar order in the dilute limit and numerical results for the case with hydrodynamic interactions where particles form vortices and columns.

[1] J. Palacci et al., Phys. Rev. Lett. 105, 088304 (2010)
[2] M. Enculescu and H. Stark, Phys. Rev. Lett. 107, 058301 (2011)

CPP 20.26 Tue 18:15 Poster C
Clustering and chemotactic collapse in a system of self-phoretic active particles — •Oliver Pohl and Holger Stark — Institut für Theoretische Physik, Technische Universität Berlin, D-10623 Berlin, Germany

Recent experiments of active colloids show a coexistence of single particles and clusters [1]. In such a "hot-cluster state" the clusters are themselves active and their sizes vary in time. In our model we separate two phoretic effects where the first accounts for activity and the second for interactions between the particles. Each colloid produces a gradient of a chemical which generates phoretic motion of nearby colloids; similar to bacteria moving along gradients of chemicals.

A hot-cluster state is reproduced which, depending on two parameters controlling interaction and activity, may exhibit a collapse to a single-cluster state. Such a collapse as well as the hot-cluster state have experimentally been observed in colonies of self-propelling bacteria [2,3]. The hot-cluster state is characterized by a power-law cluster distribution. Using a theory for nucleation and growth of clusters, we explain how clustering initiated by chemotaxis may be distinguished from clustering of particles with purely steric interactions.

[1] I. Theurkauff, C. Cottin-Bizonne, J. Palacci, C. Ybert, and L. Bocquet, Phys. Rev. Lett. **108**, 268303 (2012).
[2] F. Peruani, J. Starrus, V. Jakovljevic, L. Søgaard-Andersen, A. Deutsch, and M. Bär, Phys. Rev. Lett. **108**, 098102 (2012).

[3] E. Budrene, and H. Berg, Nature **349**, 630 (1991).

CPP 20.27 Tue 18:15 Poster C

Immunoglobulin G in Solution with Polyethylene Glycol: Protein Interaction and Phase Transitions — •Bo Jing[1], Anastasia Dietrich[1], Saliba Barsaume[1], Fajun Zhang[1], Michael Sztucki[2], and Frank Schreiber[1] — [1]Institute of Applied Physics, University of Tübingen — [2]ESRF, Grenoble, France

Immunoglobulin G (IgG) plays a crucial role in the immune response by interacting with the proteins of pathogens. In addition, the interaction of IgG with itself and the resulting liquid-liquid phase separation (LLPS) or crystallization is also of great interest, e.g. for the understanding of cryoglobulinemia and for pharmaceutical applications. In these cases, it is desirable to control the phase behaviour of IgG in solution. We achieve this through the addition of polyethylene glycol (PEG) to bovine plasma IgG solutions, which allows us to tune the range and strength of short-range attractive interactions between IgG molecules. We measured the IgG PEG solutions by small-angle X-ray scattering (SAXS) and we observed a significant dependence of the interaction on IgG concentration, PEG molecular weight and concentration as well as temperature. The two-Yukawa potential is used to fit our data, and the so obtained potential parameters are associated with the detailed phase diagrams which we compiled over the same four parameters. Thereby, we identify quantitative conditions on the interaction potential under which phase transitions occur in IgG PEG solutions. These findings allow us to assess the significance of specific, anisotropic interactions between IgG molecules in the explanation of the observed SAXS data and macroscopic phase behaviour.

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On the Formation of Clusters in Protein Solutions Upon Addition of Multivalent Ions — •Daniel Soraruf[1], Fajun Zhang[1], Felix Roosen-Runge[1], Tilo Seydel[1], Ralf Schweins[2], and Frank Schreiber[2] — [1]Institut für Angewandte Physik, Tübingen — [2]ILL, Grenoble, France

Formation of clusters of proteins in solution are currently of strong fundamental interest, and also of enormous practical interest, from amyloidogenic diseases to food and pharma industry. Current research focuses on the mechanism of protein clustering, its role in phase transitions, the lifetime and stability of clusters. We investigate protein solutions of bovine serum albumin (BSA) with YCl_3. The system exhibits a reentrant transition, characterized by the boundaries c^* and c^{**} for the concentration of Y^{3+} ions; in between the system is in a condensed regime[1]. We study the formation of clusters approaching c^* by means of SLS/DLS, obtaining information about diffusion coefficient, compressibility, and size of the clusters[2]. A continuous decrease in diffusion coefficient and increase in overall scattered intensity reveal the formation of aggregates of 100 nm in solution, which are stable over days. The inverse forward scattering intensity decreases linearly over a broad salt concentration range and the compressibility diverges close to c^*. Results from different protein concentrations can be rescaled into a master curve as a function of normalized c_{salt}/c^*. The formation of the clusters could be related to charge balance and patchy attraction of the proteins. [1] F. Zhang et al., PRL **101**, 2008, 148101;[2] Roosen-Runge et al., PNAS **108**,2012, 11815.

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Phase separation patterns in colloidal suspensions of anisotropic pigment particles — •Kathrin May, Alexey Eremin, and Ralf Stannarius — Institute of Experimental Physics, Faculty for Natural Science, Otto von Guericke University Magdeburg, Universitätsplatz 2, 39106 Magdeburg, Germany

The physics of colloidal suspensions of anisotropic particles has been a topic of research since almost a decade now. Such suspensions show a variety of unique properties depending on the particle concentration and on external fields. Here, we report the relaxation of electric-field-induced inhomogeneities in particle concentration. The occurring patterns can be static or dynamic. For our experiments, we use electro-responsive suspensions of pigment particles 'Novoperm Carmine HF3C' (Clariant) with an aspect ratio of about 1:5 in a nonpolar solvent.

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Mechanical load on colloidal and granular systems observed by fast confocal microscopy — •Günter K. Auernhammer, Marcel Roth, Manos Anyfantakis, Jennifer Wenzl, and Hans-Jürgen Butt — Max-Planck-Institut für Polymerforschung, Mainz, Germany

Densely packed colloidal and granular systems under mechanical load may show significant internal reorganization on a microscopy level. On a macroscopic level these reorganizations lead to permanent (plastic) deformations of the sample even at vanishing deformations of the colloids or granulates [1,2]. We use a combination of fast confocal microscopy (frame rate up to 500 Hz) [3] and nano indentation to explore the influence of a finite speed of the deformation on the reorganization dynamics. We also address specific changes that arise when switching form deformation controlled to stress controlled experiments.

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CPP 20.31 Tue 18:15 Poster C

Wettability controlled transfer of colloidal assemblies from wrinkled elastomers — Christoph Hanske[1], •Mareen Müller[1], Vera Bieber[1], Moritz Tebbe[1], Sarah Jessl[1], Alexander Wittemann[2], and Andreas Fery[1] — [1]University of Bayreuth, Germany — [2]University of Konstanz, Germany

Assemblies of nanoparticles are promising building blocks for future sensoric devices. Highly ordered arrays of nanoparticles can be realized by convective assembly on surface-wrinkled elastomers.[1] Recently, this lithography-free procedure was developed further to allow subsequent particle transfer to solid substrates, which is a prerequisite for many technological applications.[2] Compatibility with a variety of functional particles was also demonstrated. In this contribution we discuss the roles of capillary forces and surface wettability for the wet transfer of colloidal assemblies. In contrast to adhesion-based printing or lift-off methods, conformal contact between the particles and the target substrate is not required. However, successful particle transfer depends on the wettability of the target substrate and is inhibited efficiently by a hydrophobic monolayer.[3] We demonstrate that chemically patterned substrates are sufficient to control the particle transfer locally with excellent precision. Our method is robust enough to conduct multiple deposition steps, resulting in hierarchical colloidal structures with potential applications in plasmonic sensing or the construction of metamaterials. [1] C. Lu, et al., Soft Matter 2007, 3, 1530. [2] M. Müller, et al., Nanoscale 2012, 4, 2491. [3] C. Hanske, et al., Langmuir 2012. 10.1021/la304028f

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Hydrodynamic dispersion of micron-sized colloids in micro structured porous media — •Frank Wirner[1], Christian Scholz[1], and Clemens Bechinger[1,2] — [1]2. Physikalisches Institut, Universität Stuttgart, Germany — [2]Max-Planck-Institut für Intelligente Systeme, Stuttgart, Germany

Hydrodynamic dispersion of solutes and colloids in porous media occurs under the combined actions of a spatially varying velocity field that is caused by the morphology of the porous matrix and molecular diffusion. This spreading apart of initially adjacent colloids is important to a wide variety of processes such as secondary oil recovery, groundwater pollution or blood perfusion inside the body.

We study the dispersion of diluted suspensions of micron-sized colloids in quasi-2D microporous structures, created using soft lithography, over a wide range of Péclet numbers and porosities. A camera system is used to track individual particles and analyze their trajectories. From the obtained trajectories we calculate the velocity field of the particles and determine the first-passage-time distributions that in turn are related to the dispersion coefficients. The porous structures are artificially designed and therefore the structural parameters like Minkowski functionals and pore size distributions are fully known and can be related to the first-passage-time distributions. We discuss the effects that lead to long-tailed distributions.

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Positron annihilation lifetime spectroscopy in a porous liquid — •Tönjes Koschine[1], Klaus Rätzke[1], Nicola Giri[2], and Stuart L. James[2] — [1]Christian-Albrechts-Universität Kiel, Institute for Material Science - Multicomponent Materials, Kaiserstraße 2, Kiel, Germany — [2]School of Chemistry and Chemical Engineering, Queen's University Belfast, Stranmilis Road, Belfast, Northern Ireland

Porous liquids (PL), or liquids with intrinsic porosity, are a new type

of material [1]. In contrast to well known cavities between molecules of a liquid (extrinsic porosity), intrinsic porosity refers to empty voids within the molecules. The materials are composed of rigid cages to which short hydrocarbon tails or cyclic crown ethers are attached to endow liquid-like behavior, or very high solubility in liquid crown ether solvents respectively. The main question is whether such side groups or solvent molecules remain outside the cage cavities or whether they are able to occupy the cage cavities over time. Positron annihilation lifetime spectroscopy (PALS) is a suitable tool to detect empty pores in the sub-nanometer range. The measured orthopositronium lifetime is directly related to the pore size by the Tao-Eldrup model. Two different series of PL were studied at various temperatures by PALS to find evidence for permanent intrinsic porosity. A detailed analysis of the spectra as function of temperature, involving both PL and control materials, allowed clear separation of the lifetime due to the side groups and lifetime due to the empty pores in the PL. Thus, we were able to prove that the pores in these liquids are indeed permanently empty.

[1]O Reilly, N.; Giri, N.; James, S.L.:Chem.Eur.J.,13,2007,3020-3025.

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The effect of topology on the conformations of cyclic polymers in melts — •MICHAEL LANG[1], JAKOB FISCHER[1,2], and JENS-UWE SOMMER[1,2] — [1]Leibniz Institut für Polymerforschung Dresden, Hohe Straße 6, 01069 Dresden — [2]Institut für Theoretische Physik, Technische Universität Dresden, 01069 Dresden

The bond fluctuation method is used to simulate solutions and melts of entangled and interpenetrating cyclic polymers. The swelling of interpenetrating rings upon dilution follows the same laws as for linear chains. We find an exponential decay of the knotting probability of cyclic polymers as function of the number of blobs per chain. A power law dependence $f_n \sim \phi R^2 \sim \phi^{0.77} N$ for the average number f_n of linked rings of N monomers per cyclic polymer at polymer volume fractions ϕ larger than the overlap volume fraction of rings ϕ^* is determined from the simulation data. The fraction of non-concatenated cyclic polymers displays an exponential decay $P_{OO} \sim \exp(-f_n)$, which indicates f_n to provide the entropic effort for not forming concatenated conformations. These observations indicate four different regimes for the conformations of cyclic polymers in melts separated by characteristic lengths N_{OO}, N_C and N^* that describe the onset of the effect of non-concatenation, the cross-over between weak and strong compression and the cross-over to an overlap dominated concatenation contribution respectively. In these regimes, ring size scales as N^α with $\alpha = 1/2, 2/5, 3/8$, and $4/9$ respectively. The available data is in agreement with the first three regimes. The last regime is still unconfirmed due to the extremely large N necessary to reach this regime.

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In-situ spray deposition of colloidal thin films - a mi-crobeam GISAXS study — •STEPHAN VOLKHER ROTH[1], GUNTHARD BENECKE[1,2], SEBASTIAN BOMMEL[1], BERIT HEIDMANN[1], GERD HERZOG[1], ROMAN MANNWEILER[1], JAN PERLICH[1], JOHANNES RISCH[1], GONZALO SANTORO[1], MATTHIAS SCHWARTZKOPF[1], SHUN YU[1], KUHU SARKAR[3], and PETER MÜLLER-BUSCHBAUM[3] — [1]DESY, Notkestraße 85, D-22607 Hamburg — [2]MPI Coll. Inter. Golm, Abt. Biomat., Wissenschaftspark Potsdam-Golm, D-14424 Potsdam — [3]Lehrst. funkt. Mat., TU München, James-Franck-Str. 1, D-85748 Garching

Fast, flexible and reliable production of thin films in organic photovoltaic devices has led to the use of fluid spray deposition as one method of choice [1,2]. This method is easy to employ while at the same time yielding fully functionally devices with comparable efficiencies. Spray deposition is a complex fluidic process based on nanolitre droplets. To tailor the structure-function relationship starting from the nanoscopic level, it is therefore mandatory to understand the layer formation during the spraying process in-situ. We combined colloidal solution spraying and grazing incidence small-angle x-ray scattering in-situ to explore the rapid structural build-up during spraying as a function of different solvents and especially as a function of temperature. We present our results on this high-throughput combinatorial study and show that especially the latter parameter is crucial to obtain homogenous thin polymeric films. [1] Vak et al., Appl. Phys. Lett. 91, 081102 (2007) [2] Alaa et al., Adv. Funct. Mat. 22, 4078 (2012)

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Determining the shear viscosity of a solvent in the presence of electric fields — •ZORAN MILIČEVIĆ[1], DAVID M. SMITH[2], and ANA-SUNČANA SMITH[1] — [1]Institut für Theoretische Physik and Cluster of Excellence: Engineering of Advanced Materials, Universität Erlangen-Nürnberg, Erlangen, Germany — [2]Computer Chemie Centrum, Universität Erlangen-Nürnberg, Erlangen, Germany

The shear viscosity is a very important kinetic property characterizing the macroscopic properties of molecular systems and is hence useful for the parametrization of reliable force fields. However, calculating the shear and bulk viscosities from molecular dynamics simulations is still a challenging task.

Here we study the shear viscosity of water by performing extensive MD simulations using the GROMACS software package and SPC/E model of water (rigid and flexible) as a function of the electric field strength. The latter breaks the otherwise isotropic nature of the solvent. The shear viscosity is related to the autocorrelation function of the off-diagonal elements of the pressure tensor by the Green-Kubo relation, which is used to analyze pure water simulations. Alternatively, the viscosity is calculated from the mobility of a spherical particle, the latter arising from the diffusion constant evaluated in independent simulations. Apart from the fact that different treatments show excellent agreement, we find that the field decreases the component of the shear viscosity perpendicular to the field and increases the components parallel to the field.