CPP 25: Colloids and Complex Liquids I - Structure

Time: Wednesday 10:30–13:00 Location: ZEU 222

Topical Talk CPP 25.1 Wed 10:30 ZEU 222

From elementary building blocks towards colloidal molecules — Claudia Simone Wagner and •Alexander Wittemann — Physikalische Chemie I, Universität Bayreuth, Universitätsstr. 30, 95440 Bayreuth, Germany.

We report on the fabrication of clusters and binary colloidal composites made from organic and inorganic nanoparticles. Control over the assembly of nanoscale functional building units is of great significance to practical applications, but is also interesting from a more fundamental point of view of understanding the self-assembly of nanostructured materials. Joining together different spherical nanoparticles in a defined manner allows control over the shape, composition and surface roughness of the nanocomposites. If the constituents consist of different materials, the resulting heteroaggregates feature both compositional and interfacial anisotropy, offering unprecedented perspectives for rationally designed functional colloids, which are of fundamental importance to a broad range of applications including sensing, photonic, and electronic devices. The preparation of the clusters is based on the agglomeration of particles that are dispersed in an emulsion. The droplet size distribution in the emulsion is controlled by ultrasound. The particles adsorb on the surface of the emulsion droplets (Pickering effect) and coagulate in a well-defined way during the evaporation of the (dispersed) oil phase. Using this method one can produce clusters with colloidal dimensions (<400nm). We will report on the shapes and yield of these clusters using electron microscopy, scattering methods, and differential centrifugal sedimentation.

CPP 25.2 Wed 11:00 ZEU 222

Computer simulations of cluster formation via emulsion droplet evaporation — •Andrea Fortini, Ingmar Schwarz, and Matthias Schmidt — Theoretische Physik II, Physikalisches Institut, Universität Bayreuth, D-95440 Bayreuth, Germany

Using kinetic Monte Carlo simulations, we investigate a theoretical model of colloidal particles that interact with short-ranged attraction and long-ranged repulsion. A second hard-sphere component represents emulsion droplets that interact only with an attractive well with the colloids. The potential well has a minimum at the droplet surface and induces the Pickering effect. The droplets are taken to shrink in time, in order to model experimental conditions of droplet evaporation. We investigate the resulting morphology of colloidal clusters that have formed after complete evaporation of the droplets. We find stable packings that range from sphere doublets, triangles, and tetrahedra to complex polyhedra. We compare the resulting structures with experimental results [1,2].

[1] Manoharan et al. Science (2003) 301, 483.
[2] Wagner et al. Langmuir (2008) 24, 12126.

CPP 25.3 Wed 11:15 ZEU 222

Pattern formation of colloidal suspensions by dip-coating: An in-situ grazing incidence X-ray scattering study — •Jan Perlich[1], Matthias Schwartzkopf[1], Volker Körstgens[2], Peter Müller-Buschbaum[2], Rainer Gehrke[1], and Stephan V. Roth[1] — [1]HASYLAB-DESY, Notkestr. 85, D-22603 Hamburg (Germany) — [2]TU München, Physik Department, LS Funkt. Mat., James-Franck-Str. 1, D-85748 Garching (Germany)

The dip-coating technique is one of the commonly applied methods for the preparation of thin films or the patterning of templates from polymer solutions and particle suspensions. We present an in-situ investigation of the dip-coating process of colloidal suspensions by the advanced scattering technique grazing incidence small angle X-ray scattering (GISAXS). The focus is on the real-time monitoring of the vertical dip-coating process to deliver an insight of the structural changes during pattern formation. With the selected measurement configuration a fixed spot on the sample surface is probed and the structural information at the time the contact line passes through the beam-illuminated area is obtained, hence revealing the structure at the vicinity of the flowing meniscus. After the in-situ GISAXS experiments, the as-prepared samples are analyzed by optical microscopy (OM) for an overall homogeneity check of the dip-coated thin film. Finally, the surface structures are investigated by atomic force microscopy (AFM), yielding topographic images and thus real space information about the structure heights and widths.

CPP 25.4 Wed 11:30 ZEU 222

Crystallization and vitrification of a hard sphere like colloidal model system — Markus Franke and •Hans Joachim Schöpe — Johannes Gutenberg-Universität Mainz, Institut für Physik, Staudinger Weg 7, 55099 Mainz

A complete understanding of the solidification process is one of the long standing problems in condensed matter physics. The use of colloidal model systems provides an ideal controlled experimental system to reduce this lack of knowledge. We investigated the solidification scenario in suspensions of gravity matched colloidal hard spheres (HS) using time resolved static light scattering as well as dynamic light scattering techniques. A detailed analysis of crystal nucleation path ways shows that crystallization is originated by transient precursors (structurally heterogeneous clusters; structural heterogeneities) during the induction stage. Later these convert into highly ordered crystals in a fast, activated process. Following the same processes over a range of volume fractions from near freezing, to above the glass transition allows to systematically link the mechanisms involved in HS crystallization to those of the HS glass transition.

CPP 25.5 Wed 11:45 ZEU 222

Binary mixture of charged colloidal spheres with a spindle-type phase diagram — •Janina Marquis, Nina Lorenz, and Thomas Palberg — Institute of Physics, University of Mainz, Germany

Colloidal suspensions are an important model system for solid state physics and statistical mechanics. Their phase behaviour and crystallization kinetics are conveniently accessible via optical methods like light scattering and microscopy.

We have studied the phase behaviour and other properties of a deionized binary mixture of charged colloidal spheres with a size ratio of $\Gamma = \frac{a_s}{a_l} = 0.90$ and a charge ratio of $\Lambda = \frac{Z_s}{Z_l} = 0.8$ as a function of composition. Here the screened Coulomb interaction is increased by increasing the total particle number density (sulphate stabilized Polystyrene-Poly-n-Butylacrylamide copolymer particles: diameter: $2a_s = 118$nm, $2a_l = 131$nm, effective charges from elasticity: $Z_s^{\text{eff}} = 401 \pm 20$, $Z_l^{\text{eff}} = 499 \pm 21$). Both pure samples and the mixtures crystallize in a bcc structure with the latter forming random substitutional crystals. The liquidus as a function of composition stays roughly horizontal, whereas the solidus curves symmetrical to higher number densities and the coexistence region is widened to a horizontally oriented spindle. Similarities and differences to other charged sphere mixtures are discussed [1, 2].

[1] N. J. Lorenz et al.: J. Phys.: Condens. Matter 21, 464116 (2009)
[2] N. J. Lorenz, T. Palberg,: J. Chem. Phys. 133 104501 (2010)

CPP 25.6 Wed 12:00 ZEU 222

Modification of critical adsorption profiles by addition of ions — •Julian Dietrich[1], Ursula Nellen[1], and Clemens Bechinger[1,2] — [1]2. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany — [2]Max-Planck-Institut für Metallforschung, Heisenbergstraße 3, 70569 Stuttgart, Germany

In the last years there is growing interest in the use of binary liquids as dispersion medium for colloidal systems because this leads e.g. to critical Casimir forces or the formation of bicontinuous gels (bijels). We investigate the role of additional salt ions in binary mixtures close to the critical point since this may lead to interesting coupling effects between electrostatic forces and the mixtures' concentration distribution. In our experiments we study the adsorption profile of a critical water/2,6-lutidine mixture in the presence of salt ions. Such temperature-dependent profiles are obtained by measuring the variation of the permittivity with a surface plasmon resonance experiment for different types and concentrations of salts. We compare these results to chemically modified surfaces where the adsorption preference for one of the mixture's components is systematically altered.

CPP 25.7 Wed 12:15 ZEU 222

Excluded Volume Effects in the Depletion Attraction between Nanoparticles — •Maryam Naderian[1,2], Matthias Fuchs[2], and Michel Rawiso[3] — [1]Institut für Elektrochemie, Universität Ulm, Germany — [2]Universität Konstanz, Germany — [3]Institut Charles

Sadron, Strasbourg, France

We study the correlation functions and the interparticle interactions of mixtures of nonadsorbing real polymers and colloidal particles in both nanoparticle and colloid limits employing extensive numerical calculations within the framework of an integral equation method (PRISM) [1]. In our theoretical model colloidal particles considered as hard spheres and polymers are described using a form factor from Edwards-Flory mean field theory capturing self avoiding walk correlations.

Keeping the colloidal particle volume fraction low and varying the polymer concentration from infinitely dilute to semidilute we investigated the effect of the excluded volume interaction between the polymer monomers on the depletion layer and the induced interaction between the particles. Using numerical solutions of the PRISM-mPY equations the thermodynamic consistency is achieved, the radial distribution functions and second virial coefficient among the colloidal particles are investigated. At the end our theoretical predictions are compared with the existing results from the field theoretical approach [2] and the experimental data.

[1] K.S. Schweizer and J.G. Curro. Adv. Polym. Sci., 116:319, 1994.

[2] E. Eisenriegler. Field Theory of polymer Interactions. WILEY-VCH Verlag Berlin GmbH, 2005.

CPP 25.8 Wed 12:30 ZEU 222

Is there a hexatic phase in quasi-2d? — •Nadezhda Gribova, Axel Arnold, and Christian Holm — ICP, Universität Stuttgart, Stuttgart, Germany

A quasi-2d system, a 3d system that is constrained in one of the directions, is expected to combine some characteristic properties both of 2d systems and of 3d systems. One of the most interesting features of 2d systems is the existence of a hexatic phase, an intermediate phase in the liquid-to-solid transition.

The presence of this transition in quasi-2d systems is an open question, and even in 2d systems it is still under discussion. In our work we report a computer simulation study of a Lennard-Jones liquid confined in a narrow slit pore with tunable attractive walls. In order to investigate how the freezing in this system occurs, we perform an analysis using a broad range of order parameters that have been used so far to investigate the existence of the hexatic phase in 2d systems. It turns out, that although some of the parameters indicate that the system goes through a hexatic phase, other parameters exclude it. This shows that to be certain whether a system has a hexatic phase, one needs to study not only a big system, but also several order parameters to check all necessary properties. We observe an intermediate hexatic phase only in the slit with extremely attractive walls and a single layer of particles, i. e. if the system is practically perfectly 2d.

CPP 25.9 Wed 12:45 ZEU 222

Computing absolute free energies of 2d colloidal crystals under confinement — •Dorothea Wilms, Peter Virnau, and Kurt Binder — Johannes Gutenberg Universität, Mainz

A two-dimensional colloidal crystal is studied under the confinement of structured and planar walls in one direction. Introducing a misfit by placing the walls closer together leads to a structural transition from n rows to (n-1) rows of crystalline particles and the development of soliton-staircases as the left-over particles (which no longer fit into the crystalline structure if one row disappears) have to distribute themselves in the crystal.

A strong hysteresis is observed at this transition if only the stress is computed. Therefore, we have applied a recently developed method to compute absolute free energies of disordered structures in order to investigate this transition in more detail. Thus we were able to determine the transition point with much higher precision. We have also used the same method in order to compute the interfacial tension of the crystal with the walls.