# CPP 29: Colloids and Complex Liquids I

Structure, Stabilization

Time: Wednesday 9:30–12:45 Location: ZEU 114

CPP 29.1 Wed 9:30 ZEU 114

**Periodic Average Structures of Colloidal Monolayers on 1D Quasicrystalline Substrates** — •Lamiss Zaidouny[1], Thomas Bohlein[1], Johannes Roth[2], and Clemens Bechinger[1,3] — [1]2. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany — [2]Institut für Theoretische und Angewandte (ITAP), Pfaffenwaldring 57, 70550 Stuttgart, Germany — [3]Max-Planck-Institut für Intelligente systems, Stuttgart, Germany

We experimentally demonstrate that a colloidal monolayer with repulsive pair interaction which is subjected to a 1D quasiperiodic substrate light potential can lead to the formation of a periodic density modulation perpendicular to the orientation of the substrate. Interestingly, the periodicity does not coincide with one of the quasiperiodic length scales and is also independent of the particle number density over a wide range. Our findings are in quantitative agreement with the concept of periodic average structures (PAS) of quasicrystals (QC) which have been introduced by Janner, Janssen and de Wolf (1). The study of this concept in our experiments can lead to understand the QC-C transformations observed in atomic systems, as for example in metallic alloys (2,3). (1) P. M. de Wolf, T. Janssen and A. Janner. Acta Crystallogr, A37, 625, 1981 (2) E. Abe, A.P. Tsai, PRL 83,4 (1999) (3) B. Grushko, D. Holland-Moritz, R. Wittman, G. Wild, Alloys Comp. 280, 215-230 (1998)

CPP 29.2 Wed 9:45 ZEU 114

**Influence of electric and magnetic fields on colloidal suspensions of anisometric pigment particles** — •Kathrin May[1], Alexey Eremin[1], Susanne Klein[2], and Ralf Stannarius[1] — [1]Otto-von-Guericke Universität, FNW/IEP/ANP, 39106 Magdeburg, Germany — [2]HP Laboratories, Long Down Avenue, Stoke Gifford, Bristol BS34 8QZ, UK

Suspensions of anisometric nanoparticles show a wide range of interesting characteristics, like their concentration dependent phase behavior and response to electric and magnetic fields. Specifically the electro- and magneto-optical switching by aligning the colloidal particles in electric or magnetic fields makes them good candidates for the development of new devices.

The investigated colloidal particles are rod-shaped commercial pigment particles stabilized with a polymer and suspended in dodecane. They have an aspect ratio of about 5. This anisometry leads to the formation of ordered phases at concentrations above 15 wt%. In electric AC fields, the suspension can be electrically switched. In addition, the alignment of the colloidal particles in a magnetic field is investigated. For the pure suspension, very high magnetic fields in the range of 25 T are necessary. To increase the response to magnetic fields the suspensions are doped with magnetic nanoparticles. This is expected to reduce the critical magnetic field strength needed to align the pigment particles.

CPP 29.3 Wed 10:00 ZEU 114

**Self-assembly of colloids driven by disclinations in a nematic host fluid** — •Marco G. Mazza[1], Michael Melle[2], Sergej Schlotthauer[2], and Martin Schoen[2,3] — [1]MPI-DS, Göttingen, Germany — [2]TU Berlin, Berlin, Germany — [3]NCSU, Raleigh NC, USA

We present Monte Carlo simulations of a pair of colloidal particles immersed in a nematic host fluid. Through a calculation of the local director field we show that a pair of homogeneous colloids with locally planar anchoring surfaces attract each other if their center-of-mass distance vector forms an angle $\theta \simeq 30^\circ$ with the far-field director. We ascribe this attraction to a change in the complex three-dimensional defect structure building around the colloids and changing as the angle varies. This result settles a long-standing discrepancy between theory and experiment.

CPP 29.4 Wed 10:15 ZEU 114

**Structural anisotropy of directionally dried colloids** — •Lucas Goehring[1], François Boulogne[2], Ludovic Pauchard[2], Frédérique Giorgiutti-Dauphiné[2], Robert Botet[2], Ralf Schweins[3], Michael Sztucki[4], Joaquim Li[5], and Bernard Cabane[5] — [1]MPI Dynamics and Self-Organization, Göttingen, Germany — [2]University Paris-Sud, Orsay, France — [3]ILL, Grenoble, France — [4]ESRF, Grenoble, France — [5]PMMH, ESPCI, Paris, France

There are two main routes for making materials. In many cases the liquid-solid transition results from cooling, as intermolecular forces cause atoms to settle into equilibrium positions. For particulate materials such as ceramics and coatings the usual route is, instead, through the liquid-solid transition that is caused by evaporation from a dispersion of solid particles in a volatile solvent. One often sees this transition as being driven exclusively by the loss of free volume, and the solvent disappears from the description. Here we show, however, that the flow of solvent in a directionally dried colloidal dispersion breaks the orientational symmetry of the liquid and generates a structural anisotropy. This anisotropy arises when the particles have been concentrated by the flow to the point where they are caged by their neighbours into a soft, deformable network. The dispersion then acts as a yield-stress material, and accumulates strain in the direction of solidification, which freezes into the structure of the aggregated solid. To our knowledge, such bulk structural anisotropy has never been reported before, although we show experimentally that it is a robust feature of drying, and affects the optical and mechanical properties of the final solid.

CPP 29.5 Wed 10:30 ZEU 114

**Shear banding in colloidal dispersions** — •Pree-cha Kiatkirakajorn[1,2] and Lucas Goehring[1] — [1]Max Planck Institute for Dynamics and Self-Organization, Am Fassberg 17, D-37077 Göttingen, Germany — [2]Faculty of Physics, University of Göttingen, Friedrich-Hund-Platz 1, D-37077 Göttingen,Germany

During the drying of colloidal dispersions, a pattern of bands frequently appears in the film behind the drying front, and oriented at an angle of 45° to the drying front line. The nature of these bands has never been explained, although they have been suggested to be shear-banding based on a visual similarity to these in metals. Through microscopy of colloidal polystyrene (98-298 nanometers), we confirm that the bands are associated with local shear strains. We show how defects and shear localization arises during the drying of colloidal dispersions, and how a driving force for the bands arises from the compression of the dispersions during solidification. Further, we find that the spacing of the shear bands correlates with the film thickness, suggesting a mechanical release of stress, similar to cracking. When a new shear band starts, it can propagate either forwards or backwards, at a speed much greater than the drying front speed. Adding salt (between 0-30 mM NaCl) into the drying dispersions causes a reduction in spacing and the ultimate disappearance of the shear bands. All these observations are consistent with the simple explanation that the bands are a shear-localizing instability, caused by colloidal interactions during the directional solidification of colloidal dispersions and suggest how they can be controlled or eliminated.

CPP 29.6 Wed 10:45 ZEU 114

**Crystallization of quasiantiferromagnetic colloids** — •Gabi Steinbach[1,2], Sibylle Gemming[1,2], and Artur Erbe[1] — [1]Institute of Ion Beam Physics and Materials Research, Helmholtz-Center Dresden-Rossendorf, D-01314 Dresden — [2]Institute of Physics, Chemnitz University of Technology, D-09107 Chemnitz

The microscopic interactions between atomic magnetic moments determine the macroscopic magnetic properties of matter. For strongly correlated magnetic systems the local spin configuration plays a key role. High relaxation times, however, make direct investigations of dynamic processes such as crystallization very difficult. Here, we present an artificial spin system of magnetic colloids, which are often discussed as potential mesoscopic model systems for condensed matter. The very low relaxation rates of interacting colloids enable the visualization of phase transitions or crystallization processes by video microscopy. The used colloids have a predefined net magnetic moment, as analogue to the atomic spin. These micromagnets show a quasiantiferromagnetic interaction. They form two-dimensional hexagonal clusters with a spin configuration similar to the 120° antiferromagnetic Neel state in the cluster center and strong deviations along the edges. The cluster size

emerged as critical parameter for the occurrence of spin defects. During the cluster growth the total magnetization of the system increased in discrete steps. Further we obtained a linear increase of the inverse spin pair correlation for particles in the center. The influence of an external constant or uctuating magnetic field is investigated as control tool for cluster growth and defect formation.

**15 min. break**

CPP 29.7 Wed 11:15 ZEU 114

**Birefringence Analysis of the Effect of Electric Fields on the Order-Disorder Transition Temperature in Concentrated Solutions of Block-Copolymers** — •Christine Kathrein, Christian Pester, Heiko Schoberth, and Alexander Böker — Lehrstuhl für Makromolekulare Materialien und Oberflächen, DWI an der RWTH Aachen e.V., RWTH Aachen University, D-52056 Aachen, Germany

The application of electric fields is known to stabilize the disordered phase in concentrated solutions of lamellae forming block copolymers.

We address the fundamentally-important problem of the effect of dc electric fields on the order-disorder transition (ODT) temperature in microphase separated systems by performing in-situ birefringence measurements, and we compare this approach with the conventional high-throughput small angle X-ray scattering (SAXS) method. We studied concentrated solutions of block-copolymers in non-selective solvents with varied chemical- and volume composition. For both lamella and cylinder forming block-copolymers heating through the ODT temperature is accompanied by a continuous decrease in phase retardation. Birefringence has the advantage of being a non-destructive, facile method with high-throughput capacity. Moreover, the method has a very high sensitivity in detecting small thermal changes allowing a precise determination of the phase transition temperature.

The effect of various parameters such as dielectric contrast, chain length, solvent polarity and heating rate on the electric field induced shift of the ODT temperature is evaluated. Reported results provide new insights into the physics of confined chains under external fields.

CPP 29.8 Wed 11:30 ZEU 114

**Nanoparticle stabilized aqueous foams: Correlation with interfacial nanoparticle adsorption** — •Adrian Carl, Anne Bannuscher, and Regine v. Klitzing — TU Berlin, Institut für Physikalische Chemie, Straße des 17. Juni 124, 10623 Berlin

Silica nanoparticles can become effective foam stabilizers when they are partially hydrophobized. Foams were prepared from dispersions of silica nanoparticles with different degrees of hydrophobic modification by a short chain amine. The samples show strong synergistic effects in terms of foamability and foam stability compared to solutions that contain the hydrophobic amine or unmodified silica particles only. The systems were characterized at various length scales from the nanometer to the centimeter scale. We determine the contact angle of the nanoparticles at the air water interface via x-ray reflectivity. With increasing hydrophobicity, the nanoparticles form a colloidal network around the air bubbles, whereby the apparent fractal dimension of the network shows a strong effect on foamability and foam structure.

CPP 29.9 Wed 11:45 ZEU 114

**Magnetic Janus Particle: What Can a Toy Model Show?** — •Ekaterina Novak[1] and Sofia Kantorovich[1,2] — [1]Ural Federal University, Lenin av. 51, Ekaterinburg,620000, Russia — [2]University of Vienna, Sensengasse 8, 1090, Wien, Austria

The term Janus particle was introduced already 20 years ago in [Casagrande et al., Acad. Sci. II, 1988], whereas magnetic Janus particles were synthesized only recently [Zhao et al., Adv. Mater., 2009], [S. K. Smoukov et al, Soft Matter, 2009] and it has attracted considerable attention in literature because of their unique properties, especially, in the presence of an external magnetic field [Ruditskiy et al., Soft Mater, 2013]. Magnetic Janus particles are usually micron sized and have 2 "sides", in our case - half of the particle is made of a magnetic material, and the other half of silica. The analytical microstructure investigation methods and theoretical analysis of these systems is not yet fully worked out. However, due to the similarities, one can extend and use methods for capped colloids and regular magnetic fluids (see above) to handle the systems of magnetic Janus particles both at low and room temperatures. So we propose a simple toy model in which the spherical particle is divided into two hemispheres one of which contains a point dipole parallel to the division plane. We employ computer simulations and two different theoretical approaches (DFT and ground-sate calculations) to understand the influence of the dipolar position and dipole-external field coupling on the cluster topology and cluster-size distributions.

CPP 29.10 Wed 12:00 ZEU 114

**Structural micro and macroproperties of the magnetic anisotropic particles systems** — •Elena Pyanzina[1], Alla Muratova[1], and Sofia Kantorovich[1,2] — [1]Ural Federal University, Lenin av. 51, 620000, Ekaterinburg, Russia — [2]University of Vienna, Sensengasse 8, 1090, Wien, Austria

Magnetic anisotropic particles in the last several years became an independent fast-emerging branch of dipolar soft matter research. In this contribution we focus our attention on the magnetic particles with shape anisotropy (essentially ellipsoids), which leads to the orientation-dependent steric interparticle interaction. The magnetic part of the interaction will be characterized by simple magnetic dipole-dipole interaction, with the dipole moment being always fixed in the particle's centre of mass, but with different orientation (along/perpendicular to the main axis). We present the study of microstructure and macroscopical properties (e.g., compressibility and diffusion coefficient) for the systems with different dipole orientation and particle anisotropy. We show that cluster topology, size-distribution, and average magnetic moment strongly depend on the system parameters. As a result macroscopic responses of the systems drastically change with particle anisotropy and the dipole orientation. This may prove to be very important in various medical and industrial applications, where a bottom up design of materials plays a crucial part.

CPP 29.11 Wed 12:15 ZEU 114

**Magnetically controlled supramolecular brushes** — •Pedro A. Sánchez[1], Joan J. Cerdà[2], Tomás Sintes[2], and Sofia Kantorovich[1,3] — [1]University of Vienna, Sensengasse 8, 1090, Wien, Austria. — [2]Instituto de Física Interdisciplinar y Sistemas Complejos (UIB-CSIC), E-07122 Palma de Mallorca, Spain. — [3]Ural Federal University, Lenin av. 51, Ekaterinburg, 620000, Russia.

The creation of materials with functional surfaces is currently a key topic in nanotechnology. Numerous approaches have been proposed in recent years in order to synthesize coatings that react to different applied stimuli or environment conditions. In most cases such approaches include polymers and polyelectrolytes as building blocks of brushes with a structural behavior controlled by parameters like the temperature, pH or salt concentration of the background fluid, or the presence of an external electric field. The most recent and sophisticated systems also include colloids of diverse materials embedded or grafted in the polymeric brush, either as control or functional elements. In this context, magnetic colloids represent a promising alternative for the design of advanced functional surfaces that remains mostly unexplored. Our study is intended to determine the possibilities of magnetic colloids as the basis of supramolecular brushes that may change their properties under the control of an external magnetic field. In particular, we focus on the effects of the magnetic interactions on the structural behavior of the brushes. We employ different modeling approaches that include analytical calculations and coarse-grained computer simulations to investigate the subject.

CPP 29.12 Wed 12:30 ZEU 114

**Structure and phase behavior of n-alkyl-PEO polymer micelles** — •Matthias Amann, Lutz Willner, Jörg Stellbrink, Aurel Radulescu, and Dieter Richter — JCNS-1 & ICS-1, Forschungszentrum Jülich GmbH, D-52425 Jülich

We examine the structure of star-like n-alkyl-PEO polymer micelles in water as a function of polymer concentration with small-angle neutron scattering (SANS) methods. We present a temperature-quench-experiment to determine the aggregation number $N_{agg}$ of the micelles in the semidilute regime, exploiting the well-known unimer exchange kinetics of our model system [1]. Furthermore, we investigate the phase behavior of the model system using high resolution SANS and discuss it with regard to a theoretical phase diagram for star-polymers, based on an ultrasoft interaction potential.

We found that the aggregation number $N_{agg} = 100$ of n-alkyl-PEO micelles is independent of polymer concentration, which contradicts theoretical considerations for star-like micelles predicting a strong increase of $N_{agg}$ above the overlap concentration $\phi^*$. Near the overlap concentration $\phi^*$, a phase transition from liquid to a crystalline phase was observed. By analyzing the experimental structure factor of the polymer solutions, the crystalline phase could be identified as a fcc-crystal, which is in good agreement with theory.

References: [1] Zinn et al., Soft Matter **2012**, 8, 623-626.