CPP 36: Colloids and Complex Liquids II

Stabilization, Flow/Fields

Time: Wednesday 15:00–18:15 Location: ZEU 114

CPP 36.1 Wed 15:00 ZEU 114

Colloidal stabilization by unattached homopolymers, when does depletion repulsion play a role — •Jochen Schneider and Eckhard Bartsch — Institut für Makromolekulare Chemie/Institut für Physikalische Chemie – Albert Ludwigs Universität Freiburg, Deutschland

It is well known that the addition of non-adsorbing polymers to a dispersion of hard sphere like (HS) colloidal particles introduces short range attraction to the system. This so called depletion attraction can be used to study flocculation or the phase-behaviour of colloidal systems with short range attraction. Beside this polymer-induced (PI) attraction in some cases a PI repulsion can be observed. So far a (re-)stabilisation of a flocced phase by PI repulsion could only be observed in stericaly stabilised particles having thick stabilisation layers. Whether restabilisation can be realised in a true HS system is not yet known. Recently Semenov et al. published theoretical work on colloid-polymer-mixtures, where they predicted restabilisation in a HS system in the case of large particles and much smaller polymers, but these predictions have not yet been tested experimentally.

To gain experimental access to the influence of PI interactions on particle interactions, we study the osmotic compressibility of HS systems using turbidimetry. So far similar experiments where only carried out on rather small particles, where PI repulsion is of no importance. Thus we are extending the method towards larger particle sizes to check whether the PI stabilisation described by Semenov is able to give a more satisfying description of the data than the classic approaches.

CPP 36.2 Wed 15:15 ZEU 114

The collapse of colloidal monolayers by capillary attraction — Johannes Bleibel[1], Alvaro Dominguez[2], and •Martin Oettel[1] — [1]Institut für Angewandte Physik, Universität Tübingen — [2]Fisica Teorica, Universidad de Sevilla

We investigate the evolution of a system of colloidal particles trapped at a fluid interface and interacting via capillary attraction, as function of the range of the capillary interaction and temperature. We address the collapse of a homogeneous particle distribution and of a radially symmetric (disk–shaped) distribution of finite size, both theoretically by using a perturbative approach inspired by cosmological models, as well as numerically by means of Brownian Dynamics and Dynamical Density Functional Theory. We find a "dynamic phase diagram", exhibiting a smooth crossover from collective (gravitational–like) collapse to local (spinodal–like) clustering. In the crossover region, the evolution exhibits a peculiar shock wave behavior at the outer rim of the disk–shaped distribution.

CPP 36.3 Wed 15:30 ZEU 114

Fluorescence Correlation Spectroscopy Directly Monitors the Equilibrium Chain Exchange Kinetics of Diblock Copolymer Micelles — •David Schaeffel, Andreas Kreyes, Yi Zhaou, Daniel Crespy, Katharina Landfester, Hans-Jürgen Butt, and Kaloian Koynov — Max Planck Institute for Polymer Research, Mainz, Germany

We present a new method for monitoring the equilibrium exchange kinetics of building molecules between amphiphilic diblock copolymer micelles. The method is based on dual color fluorescence cross correlation spectroscopy (DC FCCS) and offers single molecule sensitivity. We demonstrate its versatility by studying polystyrene-block-poly[oligo(ethylene glycol) methyl ether methacrylate] (PS-b-POEGMA) micelles in different selective solvents and solvent-mixtures at various temperatures. If pure water is used as a selective solvent, no exchange could be observed at temperatures below the glass transition of the core forming PS block. In methanol, the exchange persists even at temperatures well below the PS glass transition suggesting that the methanol swells the micelles core. However, adding only small amounts of bad or good solvents can slow down or fasten the kinetics by orders of magnitude. Our findings demonstrate that DC FCCS is a fast and reliable tool to study the dynamic equilibrium exchange kinetics of copolymer micelles.

CPP 36.4 Wed 15:45 ZEU 114

Sub-millisecond dynamics of vesicles formation — •Rita Graceffa[1,2], Sagar V. Kathuria[3], Raul A. Barrea[1], R. Paul Nobrega[3], Srinivas Chakravarthy[1], Osman Bilsel[3], Thomas C. Irving[1] und Thomas M. Weiss[4] — [1]BioCAT, CSRRI and Department BCS, Illinois Institute of Technology, 3101 South Dearborn, Chicago, IL 60616, USA — [2]Institute for X-ray Physics, Georg-August-Universitat Goettingen, Friedrich-Hund-Platz 1, 37077 Goettingen, Germany — [3]Department of Biochemistry and Molecular Pharmacology, University of Massachusetts Medical School, 364 Plantation Street, LRB 919, Worcester, MA 01605, USA — [4]Stanford University, Stanford Synchrotron Radiation Lightsource, 2575 Sand Hill Rd. MS69, Menlo Park, CA 94025, USA

Recently, the formation of vesicles has been studied in situ at millisecond time-scales and disk like intermediate states have been shown to exist in some mixed systems composed of zwitterionic and anionic surfactants. However, for vesicle formation from cationic-anionic surfactant mixture no such intermediates could be detected at the achieved time resolution.

We present a study of dynamics formation of unilamellar vesicles from a mixture of oppositely charged surfactants in the microseconds range. The vesicles spontaneous self-assembly was investigated by mixing anionic and cationic micelles in a micro-mixer. The reaction intermediates were probed with Small Angle X-ray and Förster Resonance Energy Transfer. The formation of the vesicles happens within the mixing time, 100 microseconds.

CPP 36.5 Wed 16:00 ZEU 114

Effects of flow on topological defects in a nematic liquid crystal near a colloid — •Tillmann Stieger[1], Martin Schoen[1,2], and Marco G. Mazza[3] — [1]Technische Universität Berlin, Straße des 17. Juni 115, 10623 Berlin, Germany — [2]North Carolina State University, 911 Partners Way, Raleigh, North Carolina 27695, USA — [3]Max Planck Institut für Dynamik und Selbstorganisation, Am Faßberg 17, 37077 Göttingen, Germany

Microfluidic applications are becoming an extremely important tool to manipulate fluids, droplets and materials at small scales. Anisotropic liquids are a promising novel approach to such applications. However, a clear understanding of the modifications induced by flow when a colloid is immersed in a liquid crystal is still missing. Our molecular dynamics simulations show that flow has in fact a significant impact on defect structures around a colloidal particle. We show that flow distorts Boojum defects into an asymmetrically larger downstream lobe, and that Saturn ring defects are convected downstream along the flow direction, which is in agreement with experimental observations [1]. Additionally, for a Janus colloid with both parallel and perpendicular patches, exhibiting a Boojum defect and a Saturn ring defect, we find that the Boojum defect facing the upstream direction is destroyed and the Saturn ring is convected downstream.

[1] S. Khullar, C. Zhou, and J. J. Feng, Phys. Rev. Lett. **99**, 237802 (2007).

CPP 36.6 Wed 16:15 ZEU 114

New fitting model for structural oscillation forces — •Sebastian Schön — Technische Universität Berlin Strasse des 17. Juni 124 D-10623 Berlin

Structural forces are a well known phenomenon in surface science. They arise due to the layering of particles in the vicinity of a confining wall. The layered structure has an oscillatory density profile in normal direction. Overlap with a second interfacial region results in an attractive or repulsive force acting on the surfaces, depending on the separation of the walls. These forces can be fitted via following formula:

$f(x) = -A * e^{(-x/\xi)} * \cos(2\pi(x-\Delta x)/\lambda)$,

where f is the force, x is the separation between the walls, A is the amplitude of the oscillations, ξ is the decay length, λ signifies the wavelength of the oscillation and Δx is the phase shift. This common fit formula can be extended by introducing an additional term of exponential decaying nature. The additional term is able to describe deviations between the common fit and data measured for aqueous suspensions of silica nanoparticles, especially at small wall to wall separations and

larger concentrations. Furthermore, it is shown that neglecting this term leads to an oscillatory behaviour depending on the starting point of the fit region of the three important fit parameters: amplitude, wavelength and decay-length. The extension enables a large increase of the data range accessible for accurate fitting, especially towards small separation and leads to the removal of the oscillatory behaviour of the fit parameters. Therefore, resulting in a strong increase of accuracy for all fit parameter in the system studied here.

15 min. break

CPP 36.7 Wed 16:45 ZEU 114

Shear banding in weakly attractive soft jammed materials — •Ehsan Irani[1], Pinaki Chaudhuri[2], and Claus Heussinger[1] — [1]Institut für Theoretische Physik, Georg-August-Universität Göttingen, Göttingen, Germany — [2]Heinrich Heine University of Düsseldorf, Düsseldorf, Germany

We study the rheology of a system of weakly attractive soft particles close to jamming. Lees-Edward boundary conditions are used to impose a shear flow in two dimensions. Shear stress as a function of shear rate shows non-monotonic behavior signaling a mechanical instability. This leads to persistent spatial heterogneities in flow, which becomes prominent with increasing system size. In the yield stress regime, a fragile solid is formed even far below the jamming point. A scaling argument is presented that connects the yield stress to the attraction strength and the connectivity of the fragile solid. The shear-banding instability is explained with the breakdown of the solid and an associated loss of structure. This mechanism could be a scenario to explain shear banding in different materials with short-range attractive forces.

CPP 36.8 Wed 17:00 ZEU 114

Writing nanoparticles lines: in-situ observation of structure formation — •Berit Heidmann[1], Matthias Schwartzkopf[1], Roman Mannweiler[1], Stephan V. Roth[1], Frans de Jong[2], and Michael Schlüter[2] — [1]DESY, Notkestr. 85, 22607 Hamburg — [2]Institute of Multiphase Flows, TUHH, Eißendorfer Str. 38, 21073 Hamburg

Adsorption of colloids on surfaces allows for tailored installation of ordered arrays of nano- and mesostructures [1]. Here, it is crucial to understand the adsorption process in-situ and follow the deposition and ordering of the colloids in line-type structures. For our in-situ investigation, we use a combination of microbeam grazing incidence small-angle x-ray scattering (GISAXS) and contact angle apparatus. The high-precision dosing system enables us to write line-type structures over macroscopic distances by depositing colloids from an aqueous solution (sub microliter) volume of nanoparticles. Such structures are useful for establishing complex conducting pathways on organic substrates without the use of designed masks. GISAXS enables us to detect the various stages of nanostructure formation, identifiable by the characteristic scattering of the gold colloids being adsorbed and chemically bound to the functionalized silicon. We present our results on the specific system gold nanoparticles on Mercapto-Propyl-Trimethoxysilanized silicon surface and correlate our nanostructural finding with UV-Vis measurements. [1] Wu, T-H., Lu, H-H. and Lin, C-W., Dependece of Transport Rate on Area of Lithography and Pretreatment of Tip in Dip-Pen Nanolithography,Langmuir,2012,28,14509-14513

CPP 36.9 Wed 17:15 ZEU 114

Stress-driven Dynamic Behavior of Free-Standing Bent-Core Liquid Crystal Filaments — •Tanya Ostapenko[1], Seyyed Muhammad Salili[2], Alexey Eremin[1], Antal Jákli[2], and Ralf Stannarius[1] — [1]Institute of Experimental Physics, Otto-von-Guericke-Universität, 39106 Magdeburg, Germany — [2]Chemical Physics Interdisciplinary Program and Liquid Crystal Institute, Kent State University, Kent, OH 44242, USA

Filament forming materials, such spider silk, collagen and cellulose, are widespread in nature [1]. The B_7 liquid crystalline phase of bent-core mesogens is an exceptionally good example of a mesophase forming very stable fluid filaments [2]. This phase is distinguished by an internal structure of strongly undulated molecular layers and spontaneous polarization with local splay. This results in an overall chiral columnar structure.

Here, we report on the dynamic behavior of free-standing bent-core liquid crystal filaments under dilative and axial compressive stresses in the B_7 phase [3]. We found that such filaments demonstrate very complex structures depending on the filament's temperature relative to the clearing point, initial filament thickness, and on the velocity at which the filament is pulled or compressed. We discuss possible reasons for the formation of such structures.

[1] F. Vollrath, D. Knight. *Nature* **410**, 541 (2001).
[2] A. Jákli, D. Krüerke, and G.G. Nair, *Phys. Rev. E* **67** (2003).
[3] T. Ostapenko, S.M. Salili, A. Eremin, A. Jákli, and R. Stannarius (submitted).

CPP 36.10 Wed 17:30 ZEU 114

Gradient diffusion in ferrofluids with chain aggregates — •Alla Muratova[1], Alexey Ivanov[1], and Sofia Kantorovich[1,2] — [1]Ural Federal University, 620000, Russia, Ekaterinburg, Lenin. av., 51 — [2]University of Vienna, Sensengasse 8, 1090, Wien, Austria

We present the results on the mobility and diffusion coefficients in the systems of magnetic dipolar particles. There were several attempts to study diffusion [Yu. A. Buyevich et al., Physica. A 190, 276 (1992); P. Ilg, Phys. Rev. E 71, 051407 (2005); J. Jordanovic et al., Phys. Rev. Lett. 106, 038301 (2011)], but the detailed theoretical description is still missing. We study how the mobility and diffusion coefficients depend on the system polydispersity, granulometric composition, geometrical constraints, and a presence of an external magnetic field. In order to know this, we consider three-dimensional and quasi-two-dimensional mono- and bidisperse systems with and without an external magnetic field. We use the obtained diffusion coefficients for calculating the distribution of chain aggregates in the gravity gradient. Also we consider different systems in dependence of different particle sizes. The main method of our theory is density functional theory. We compare our theoretical results, and explain dependence of the diffusion coefficients on some parameters. Also we compare our theoretical results to the data of the computer simulations.

CPP 36.11 Wed 17:45 ZEU 114

Smoothed particle hydrodynamics of complex fluids — •Daniel Rings and Peter Olmsted — University of Leeds

The rheology of complex liquids such as polymer solutions is of great interest in various disciplines and the commonly used theoretical research tools range from analytic phenomenological models to large-scale molecular dynamics simulations. Smoothed particle hydrodynamics (SPH) is a promising hybrid method which combines microscopic detail of a certain extent with computational efficiency. Originally invented for astrophysical calculations, this Lagrangian method approximates the solution to the (slightly compressible) Navier–Stokes equations by smoothly interpolating the fields which are evaluated at advected virtual particles. The appeal of this method is its relative ease to deal with complicated boundary conditions without the need for mesh construction and to capture spatial inhomogeneities and temporal transients. Last but not least, it can be implemented on the basis of existing molecular dynamics software.

For a fluid with a non-monotonic flow curve, we study in detail the shear banding transition and how it is affected by the presence of immersed rigid colloids. We discuss discrepancies between different apparent stress states and comment on the interpretation of results obtained within the framework of SPH—of particular interest in view of the growing use of this method in computational fluid dynamics.

CPP 36.12 Wed 18:00 ZEU 114

Melting liquid and crystalline droplets in rod-sphere dispersions by shear flow — •Donald Guu[1], Minne Pavlik Lettinga[1,2], and Jan Karel George Dhont[1,3] — [1]Forschungszentrum Juelich, Institute of Complex Systems 3, Leo-Brandt-Str, 52425 Juelich, Germany — [2]Department of Physics and Astronomy, Laboratory for Acoustics and Thermal Physics, KU Leuven, Celestijnenlaan 200D, Leuven B-3001, Belgium — [3]Heinrich-Heine-Universitaet Duesseldorf, Universitaetsstrasse 1, 40225 Duesseldorf, Germany

We determined the phase behavior of an ideal rod*sphere mixture consisting of fd-virus, which are mono-disperse colloidal rods, and density matched mono-disperse polystyrene spheres, using a combination of diffuse wave spectroscopy and optical microscopy. Equilibrium phase diagrams were mapped out for various L/R ratios, where L is length of the rod and R is the sphere radius. At high L/R we observe droplets of a liquid phase of the spherical particles, while at lower L/R we obtained clusters which are crystalline. We studied the susceptibility of the droplets to shear flow, using a counter rotating cone-plate shear cell mounted on a fast confocal microscope. We observed a shear rate dependent melting of the structures, which is a function of the location in the equilibrium phase diagram of the sheared mixture. We show that the melting of liquid droplets takes place via another mechanism than for the crystalline clusters.