

## CPP 18: Poster: Colloids and Complex Fluids

Time: Monday 18:30–21:00

Location: P1C

CPP 18.1 Mon 18:30 P1C

**Entropic interactions between dendrimers and linear chains in solution** — ●MARTIN WENGENMAYR<sup>1,2</sup>, RON DOCKHORN<sup>1,2</sup>, and JENS-UWE SOMMER<sup>1,2</sup> — <sup>1</sup>Leibniz-Institut für Polymerforschung Dresden, Germany — <sup>2</sup>Technische Universität Dresden, Germany

Entropic interactions between soft objects are not fully understood. In particular, branched polymers immersed in a melt of linear chains might segregate even without repulsive interactions between the polymers. To study these effects for a well defined system, we investigate the conformational properties of dendrimers immersed in dilute to highly concentrated polymer solutions of linear chains. A mean-field theory and large scale computer simulations utilizing the bond fluctuation model are applied to identify the solution properties and repulsive interactions between solvent and dendrimer. The free energy landscape is evaluated applying the Umbrella Monte Carlo sampling method. Our study shows that the interactions between linear polymer solution and dendrimer depend essentially on the dendrimer generation and on the polymer concentration.

CPP 18.2 Mon 18:30 P1C

**DCMIX3b: First results from microgravity experiments on the ISS** — ●THOMAS TRILLER and WERNER KÖHLER — Physikalisches Institut, Universität Bayreuth, 95440 Bayreuth, Germany

DCMIX3b is the most recent iteration of a measurement campaign, which aims to gather a reliable data basis for diffusive transport coefficients of different ternary liquid mixtures in the microgravity environment of the ISS. Special focus of these measurements is the Soret effect, a diffusive demixing driven by a temperature gradient. To get reliable reference data for ground measurements, several international research teams cooperate in the DCMIX project under the auspices of ESA and Roscosmos. DCMIX3 shall provide data for aqueous systems, containing mixtures of water / ethanol / triethylene-glycol. All samples are measured via digital optical interferometry (SODI) inside the Microgravity Science Glovebox. After the loss of the first DCMIX3 samples during the explosion of the Cygnus CRS Orb-3 transport in October 2014, measurements had to be deferred for almost two years. In July 2016, the new DCMIX3b samples were successfully delivered to the space station by SpaceX CRS-9. Starting in September 2016, a set of 30 experimental runs with 5 different compositions could be performed until the end of operations in November 2016. Full evaluation can only begin after the hard disks containing the data will be brought back to earth, probably in early 2017. Nevertheless, the available telemetry data gives a good impression of the quality of the data. On our poster, we show a first assessment, explaining the evaluation process, as well as some problems which occurred during operations.

CPP 18.3 Mon 18:30 P1C

**Optical contrast factor measurements of ternary mixtures with a multi-wavelength Michelson interferometer** — ●MARCEL SCHRAML and WERNER KÖHLER — Physikalisches Institut, Universität Bayreuth, 95440 Bayreuth, Germany

Non-isothermal diffusion in ternary mixtures is extensively studied both on ground and under microgravity conditions on the International Space Station ISS (ESA/Roscosmos, DCMIX3). In most cases are optical, contactless techniques the method of choice. These methods have the disadvantage that the measured data need to be transformed from the refraction index space into the concentration space. Therefore the contrast factor matrix  $a_{ij} = (\partial n_i / \partial c_j)_{p,T,c_k \neq j}$  has to be inverted. At least two different wavelengths are necessary to provide sufficient information for ternary mixtures. We have designed a multi-wavelength Michelson-Interferometer to get precise refraction index values over the whole spectral range measured simultaneously with the same specimen. The Michelson interferometer uses optical fibers to couple the four lasers (406nm, 543 nm, 632 nm, 934 nm) into the experimental setup. The number of wavelengths can easily be extended. The geometrical path is varied and the optical path is measured. At the moment there is no commercial setup available. On the poster we will discuss the present state of the instrument, its design and the achievable accuracy.

CPP 18.4 Mon 18:30 P1C

**Influence of added crosslinker on the kinetics of LLPS stud-**

**ied by USAXS** — ●RICHARD SCHÄUFELE<sup>1</sup>, STEFANO DA VELA<sup>1</sup>, JOHANNES MÖLLER<sup>2</sup>, FAJUN ZHANG<sup>1</sup>, and FRANK SCHREIBER<sup>1</sup> — <sup>1</sup>Institut für Angewandte Physik, Universität Tübingen, 72076 Tübingen — <sup>2</sup>ESRF, Grenoble, France

In the presence of trivalent cations, e.g.  $Y^{3+}$ , BSA solutions feature a liquid-liquid phase separation (LLPS) with a lower critical solution temperature. During LLPS the dense phase of the system can be brought to a dynamically arrested state before reaching the binodal for temperatures below denaturation.[1] By adding a bifunctional crosslinker, Glutaraldehyde, protein monomers form clusters based on inherently multiple reaction sites. Crosslinker concentration directly impacts size and size distribution of protein clusters, altering the binodal as well as the glass line. In order to understand the influence of oligomerization on the kinetics of LLPS and the arrested state, dense phases with different crosslinker concentrations are studied. The experiments focus on the kinetics during phase separation for different temperature quenches. By using time-resolved ultra small angle X-ray scattering (USAXS) complemented with DLS, the evolution of the characteristic length can be followed through the different stages of the phase separation. Surprisingly, an increasing crosslinker concentration does not display a monotonic trend considering the characteristic length. The latter as well as the behaviour of intensity and arrested state will be discussed with respect to the temporal evolution.

[1] Stefano Da Vela, et al., Soft Matter, 2016, 12, 9334-9341

CPP 18.5 Mon 18:30 P1C

**Characterization of Marangoni convections in microchannel structures** — ●DANIEL ZAPP, MICHAEL ORLISHAUSEN, LORENTZ BUTZHAMMER, and WERNER KÖHLER — Physikalisches Institut, Universität Bayreuth, 95440 Bayreuth, Germany

We have investigated Marangoni convection at the meniscus formed by a liquid-gas interface in microchannel structures with characteristic length scales of the order of 100  $\mu\text{m}$ . In ethanol-water mixtures Marangoni convection is driven both by temperature and composition gradients, in pure ethanol by temperature gradients alone. The temperature and concentration differences arise instantaneously from inhomogeneous evaporation at the liquid-gas interface but can also be induced and switched by selective laser heating. The resulting flows are visualized by polystyrene tracer particles of 600 nm in diameter under a light microscope. Particle velocities are determined via image correlation techniques. As a function of the meniscus shape, the microchannel geometry and the evaporation rate of the volatile component, either a single or two symmetric convection roles are observed. They come to a sudden halt when the evaporation of the liquid is stopped by an increase of the vapor pressure in the gas phase. Currently we are working on the pressure measurement in the microchannels. Tracer particles are repelled from stream lines that come closer to the meniscus than one particle radius. Surprisingly, this leads to large depletion zones and very efficient particle accumulation inside the vortex. We will present a quantitative analysis of the flow patterns and numerical simulations of the development of the depletion and accumulation zones.

CPP 18.6 Mon 18:30 P1C

**Binding probability model for protein cluster formation in aqueous solution** — ●MICHAL K. BRAUN<sup>1</sup>, MARCO GRIMALDO<sup>2</sup>, FELIX ROOSEN-RUNGE<sup>2</sup>, TILO SEYDEL<sup>2</sup>, FAJUN ZHANG<sup>1</sup>, and FRANK SCHREIBER<sup>1</sup> — <sup>1</sup>Institut für Angewandte Physik, Universität Tübingen, 72076 Tübingen — <sup>2</sup>ILL, Grenoble, France

Due to the specific nature of the interactions, in certain cases protein crystallization can be described by a model of globular particles with attractive patches [1]. Clusters of proteins are possible precursors for crystals. We have investigated self-diffusion [2] and collective diffusion [3] of clusters of the model protein bovine serum albumin (BSA) that form in the presence of a trivalent salt ( $YCl_3$ ). The self- and collective diffusion coefficients are obtained from neutron and dynamic light scattering (DLS) data, respectively. We present new DLS data on BSA in the presence of another trivalent salt, namely  $LaCl_3$ . Our data can be analyzed based on simple Brownian diffusion [2]. The total scattering function  $S(q, \omega)$  is linked to the model of patchy particles. In this way, the dependence of the binding probability  $p_b$  on the salt concentration is obtained. The measured self- and collective diffusion coefficients fall onto separate master curves [2,3], which only depend on the ratio of

salt and protein. In the case of self-diffusion a master curve was also found for  $p_b$ . From the new collective diffusion data  $p_b$  will be extracted analogously and will be compared to  $p_b$  from the self-diffusion data.

[1] Roosen-Runge et al., *Sci. Rep.*, **4**, 7016, 2014

[2] Grimaldo et al., *JPCL*, **6**, 2577, 2015

[3] Soraruf et al., *Soft Matter*, **10**, 894, 2014

CPP 18.7 Mon 18:30 P1C

**Influence of poly(ethylene glycol) chain length on ionic w/o microemulsions** — ●ANN-KATHRIN GREFE, ALEXANDER MATT, and BERND STÜHN — Institut für Festkörperphysik, Technische Universität Darmstadt, D-64289 Darmstadt, Germany

Microemulsions are thermodynamically stable mixtures of a hydrophilic and a hydrophobic component, stabilized by surfactants. There have been extensive studies in order to determine how the presence of foreign molecules influences the behaviour of a microemulsion.

We study the droplet phase of water-in-oil microemulsions containing the anionic surfactant dioctyl sulfosuccinate (AOT). The droplets are loaded with the water soluble polymer poly(ethylene glycol), which is expected to dissolve in the water droplets and shows attractive interactions with the surfactant shell [1]. We investigate different molecular weights of PEG ranging from 200 g/mol to 12000 g/mol. In doing so, we are able to differentiate between the influence of chain length and number of hydroxy groups. The influence of the polymer on percolation and phase separation temperature  $T_P$  and  $T_C$  is examined. To determine  $T_P$  and  $T_C$  we use dielectric spectroscopy at a frequency of 10 kHz utilizing the steep increase in conductivity as the percolation temperature is approached. In addition, the temperature dependent radii of the water droplets are investigated via small angle x-ray scattering, using the pronounced electron density contrast of the surfactant shell. By combining the results we can calculate the bending modulus of the surfactant shell.

[1] R. Wipf et al., *Colloid Polym Sci* 288, 589-601 (2010)

CPP 18.8 Mon 18:30 P1C

**Investigation of dynamical properties of a simple patchy particle model by Monte Carlo simulations** — ●MARC HABIGER, JOHANNES BLEIBEL, and MARTIN OETTEL — Institut für Angewandte Physik, Universität Tübingen, Deutschland

Patchy Particles are widely used as a model system for proteins in a solution. We propose a dynamical model for patchy colloidal particles emerging from a binary mixture of particles of different size, "colloids" and "bonds". Both colloids and bonds interact with isotropic, but non-additive hard-sphere like interactions, additionally the colloid-bond interaction contains a short-range, isotropic attraction. The maximum number of bonds on a colloid can be tuned via the repulsion between bonds and is set to four. Our model resembles a soft version of the model studied by E. Zaccarelli et al. [1]

Equilibrium and dynamical properties of the mixture are investigated by (dynamic) Monte Carlo simulations.

We have examined the equation of state, and further we investigate the self and distinct part of the dynamical structure factor and the intermediate scattering function. For the latter the dynamics can not be matched with a single exponential decay, a fact which in the context of experiments is often attributed to the formation of clusters. In this model, it is a consequence of complicated network dynamics.

[1] E. Zaccarelli, F. Sciortino, P. Tartaglia, *J. Chem. Phys.* **127**, 174501 (2007)

CPP 18.9 Mon 18:30 P1C

**Cosolvent Effects on Protein Phase Behavior** — ●JAN HANSEN, FLORIAN PLATTEN, and STEFAN U. EGELHAAF — Heinrich Heine University, Condensed Matter Physics Laboratory, Duesseldorf, Germany

Cosolvents are routinely used to modulate the stability of proteins. Yet, they also alter protein-protein interactions, which we characterize by static light scattering and in terms of the macroscopic phase behavior of protein solutions. In particular, we experimentally determined the crystallization boundary, the metastable gas-liquid binodal and the second virial coefficient of lysozyme solutions in the presence of various additives, such as sodium chloride (NaCl), guanidine hydrochloride (GuHCl), and glycerol. Our data indicate that the additives might affect the protein phase behavior through electrostatic screening and additive-specific contributions. NaCl induces attractions, glycerol and GuHCl weaken attractions and/or induce repulsions. Using a two-state thermodynamic model, the cosolvent-dependent changes of the phase boundaries can be related to the respective changes of the free energy.

Hansen et al., *PCCP*, 2016, **18**, 10270.

CPP 18.10 Mon 18:30 P1C

**Phase behavior of dense lysozyme and nanoparticle solutions** — ●JULIAN SCHULZE<sup>1</sup>, NICO KÖNIG<sup>1</sup>, KARIN JULIUS<sup>1</sup>, STEFFEN BIEDER<sup>1</sup>, MICHAEL PAULUS<sup>1</sup>, JULIA NASE<sup>1</sup>, METIN TOLAN<sup>1</sup>, and ROLAND WINTER<sup>2</sup> — <sup>1</sup>Fakultät Physik/Delta, TU Dortmund, 44221 Dortmund, Germany — <sup>2</sup>Fakultät für Chemie und Chemische Biologie, TU Dortmund, 44221 Dortmund, Germany

In previous studies, small-angle X-ray scattering was used to study the intermolecular interaction potential of lysozyme solutions under the influence of varying environmental conditions such as protein concentration,  $c$ , temperature,  $T$ , and pressure,  $p$ . The attractive part of the interaction potential exhibits a non-monotonous  $p$ -dependence with a minimum at  $\sim 2$  kbar at selected temperatures. Adding NaCl leads to more prominent attractive short range interactions, especially at high  $c$  and low  $T$ , and the homogeneous protein solution becomes turbid due to the formation of a metastable liquid-liquid phase separated (LLPS) state, where lysozyme forms small droplets of high concentration within a more dilute liquid phase. Due to depletion attraction, Ludox silica nanoparticles show a liquid-liquid phase separation as well when polymers are added. Here, we discuss differences in the mechanism and phase behavior of these dense lysozyme and nanoparticle solutions.

CPP 18.11 Mon 18:30 P1C

**Assembly of opal balls on superhydrophobic surfaces** — ●LUCIA BALDAUF and LAURA ROSSI — Universiteit van Amsterdam, Amsterdam, The Netherlands

Colloids are particles with at least one dimension in the size range of 1-1000nm. Since their size is comparable to the wavelengths of visible light, periodic structures of colloidal particles can produce materials with interesting optical properties. When these materials consist of silica spheres organized in highly regular close packed structures, we call them opals. In this work, we investigate the crystallization of silica colloids into opals from evaporating droplets on superhydrophobic surfaces [*Adv. Mat.*, **20**(22), 4263 (2008); *Macromol. Rapid Comm.*, **31**(2), 190 (2010)]. Using superhydrophobic surfaces allows us to induce an isotropic compression of the drying opal balls, rather than introducing a preferential direction by sedimentation under gravity. We study the influence of particle size, shape and surface chemistry on the crystallization process and physical properties of the resulting opals.

CPP 18.12 Mon 18:30 P1C

**Self-assembly in solutions of designed supramolecular ferromagnetic filaments** — ●EKATERINA NOVAK<sup>1</sup>, PEDRO SANCHEZ<sup>2</sup>, ELENA PYANZINA<sup>1</sup>, and SOFIA KANTOROVICH<sup>1,2</sup> — <sup>1</sup>Ural Federal University, Lenin av. 51, Ekaterinburg, 620000, Russia — <sup>2</sup>University of Vienna, Sensengasse 8, 1090, Wien, Austria

Magnetic filaments are semi-flexible polymer-like chains of magnetic nanoparticles permanently crosslinked with polymers which have been recently shown to be promising building blocks for the creation of sophisticated magneto-responsive materials (Sanchez et al, *Faraday Discuss.*, 2016). Here, we investigate magnetic filaments with different conformations made out of ferromagnetic spherical nanoparticles - simple open chains, closed rings and branched structures with "X" and "Y" junctions - inspired by the recent findings on the low temperature self-assembly and ground state of dipolar hard spheres (Kantorovich et al, *PCCP*, 2015). Using Langevin dynamics simulations, we focus on low-concentration solutions of filaments, analyzing in detail their self-assembly. Extensive cluster analysis allows to compare the structures formed by filament solutions to those observed in "conventional" magnetic fluids containing non-crosslinked nanoparticles. These results will form the basis for developing theoretical models and provide recommendations for the design of novel magneto-responsive systems.

CPP 18.13 Mon 18:30 P1C

**Investigations of designed supramolecular magnetic filaments of different topology** — ●ELENA PYANZINA<sup>1</sup>, EKATERINA NOVAK<sup>1</sup>, ANNA GUDKOVA<sup>1</sup>, PEDRO A. SÁNCHEZ<sup>2</sup>, and SOFIA KANTOROVICH<sup>1,2</sup> — <sup>1</sup>Ural Federal University, Lenin av. 51, Ekaterinburg, 620000, Russia — <sup>2</sup>University of Vienna, Sensengasse 8, 1090, Wien, Austria

Newly developed experimental techniques allowed to combine magnetic particles and polymers. These techniques make it possible to create a certain aggregated structures with finely controllable mechanical, magnetic and other properties. Here, we investigate magnetic filaments with different topologies made out of ferromagnetic spheri-

cal and ellipsoidal nanoparticles - simple open chains and closed rings which are the ground states of dipolar hard particles (Prokop'eva et al, JETP, 2011; Kantorovich et al, Soft Matter, 2013). Using Langevin dynamics simulations, we analyse different properties of filaments. Thus, we show that shape of particles, the size of their magnetic moment, temperature and filament's length can significantly change conformation and properties of a single filament. These results will form the basis for developing theoretical models and provide recommendations for the design of novel magnetoresponsive systems.

CPP 18.14 Mon 18:30 P1C

**Structure and Dynamics of Confined Liquids Studied by an X-ray Surface Force Apparatus** — ●HENNING WEISS<sup>1</sup>, JULIAN MARS<sup>1,2</sup>, HAILONG LI<sup>1</sup>, HSIU-WEI CHENG<sup>3</sup>, SADHANAA BUVANESWARAN<sup>3</sup>, CLAUDIA MEROLA<sup>3</sup>, VEIJO HONKIMAEKI<sup>4</sup>, MARKUS VALTINER<sup>3</sup>, and MARKUS MEZGER<sup>1,2</sup> — <sup>1</sup>Max-Planck-Institut für Polymerforschung, Mainz, Germany — <sup>2</sup>Institut für Physik, Johannes Gutenberg-Universität Mainz, Germany — <sup>3</sup>Max-Planck-

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Confined liquids play an important role in many technical applications and processes. Recent studies on the performance of batteries and capacitors showed that electrochemical and catalytic processes are highly sensitive to the molecular scale liquid structure adjacent to interfaces. Thus, a detailed knowledge of the structure of confined liquids on molecular length scale is of great interest for fundamental and applied sciences. To study confined structures under dynamic conditions we constructed a novel in-situ X-ray surface force apparatus (X-SFA). This device can create a precisely controlled slit pore confinement down to molecular dimensions. The normal load between the apposing interfaces can be modulated to study the structure and dynamics of confined liquids. The in-plane structure of the liquid parallel to the slit pore and density profiles perpendicular to the confining interfaces were studied by X-ray scattering and reflectivity. Relaxation processes were studied by bringing the system out of equilibrium by external stress.