CPP 12: Poster: Colloids and Complex Fluids

Time: Monday 18:15–21:00 Location: Poster B2

CPP 12.1 Mon 18:15 Poster B2

Aggregation behavior of doubly thermo-responsive polysulfobetaine-b-poly(N-isopropylmethacrylamide) diblock copolymers — •Natalya Vishnevetskaya[1], Viet Hildebrand[2], André Laschewsky[2], Peter Müller-Buschbaum[1], and Christine M. Papadakis[1] — [1]TU München, Physikdepartment, Physik weicher Materie — [2]University of Potsdam, Institute of Chemistry

Diblock copolymers consisting of a non-ionic poly(N-isopropylmethacrylamide) (PNIPMAM) block and a zwitterionic poly(sulfobetaine) (PSPP block) feature both a lower and an upper critical solution temperature (LCST and UCST) in aqueous solution. PSPP-b-PNIPMAM is expected to form (i) micelles with a PNIPMAM shell and a PSPP core or vice versa at low and high temperatures and (ii) unimers or large aggregates in the intermediate temperature range, depending on temperature, chemical structure and block length, as well as on the presence of electrolyte. The phase transition temperatures in dependence on the electrolyte concentration are investigated by turbidimetry. The aggregation behavior which is responsive to two stimuli (temperature and electrolyte concentration), and depends on the architecture of the non-ionic block, is studied by temperature-resolved small-angle neutron scattering (SANS) and dynamic light scattering (DLS). In D2O PSPP-b-PNIPMAM forms indeed micelles above the LCST and below the UCST. The micelle structures depend significantly on the block lengths, whereas the salt-induced changes are only minor.

CPP 12.2 Mon 18:15 Poster B2

Experimental study of Stokes Einstein relation for a colloidal particle in nonequilibrium viscoelastic media — •Johannes Berner[1], Juan Ruben Gomez-Solano[1], and Clemens Bechinger[1,2] — [1]2. Physikalisches Institut, Universität Stuttgart, Germany — [2]MPI for Intelligent Systems, Stuttgart, Germany

Viscoelastic fluids are of great importance in biological systems and in medical and industrial applications. Their flow properties have been extensively studied by bulk rheology [1] and more recently by microrheology [2] using embedded colloidal probes. For instance in passive microrheology the Stokes Einstein relation is used to determine such properties by measuring the thermal fluctuations of the particle position [3]. This is only valid provided that the fluid and the particle are in thermal equilibrium. However this assumption is not trivially satisfied, if the microstructure of the fluid is driven far from equilibrium, e.g. by inducing a local deformation by means of the particle [4, 5]. In this work, we investigate the validity of the Stokes Einstein relation for a colloidal particle driven by optical tweezers through several viscoelastic media. In particular we focus on dependence on the local strain and strain rate.

[1] Larson R G 1999 The Structure and Rheology of Complex Fluids (New York: Oxford University Press), [2] Squires T. M. and Mason T. G., Annu. Rev. Fluid Mech., 42 (2010) 413, [3] Mason T. G. and Weitz D. A., Phys. Rev. Lett., 74 (1995) 1250, [4] Gomez-Solano J. R. and Bechinger C., EPL, 108 (2014) 54008, [5] Gomez-Solano J. R. and Bechinger C., New J. Physics, 17 (2015) 103032

CPP 12.3 Mon 18:15 Poster B2

Interactions of self-propelled micro-swimmers in viscoelastic fluids. — •Mahsa Sahebdivani[1], Juan Ruben Gomez-Solano[1], and Clemens Bechinger[1,2] — [1]2. Physikalisches Institut, Universitaet Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany — [2]Max-Planck-Institut fuer Intelligente Systeme, Heisenbergstrasse 3, 70569 Stuttgart, Germany

The motion of many natural micro-swimmers, such as bacteria and spermatozoa, commonly takes place in viscoelastic fluids and in complex crowded environments. Contrary to the extensive studies on the motion of artificial micro-swimmers in Newtonian fluids [1], only in a few experimental works, the swimming mechanism of some microorganisms e.g. algal cells [2], and E. coli [3] has been done. In our work, we experimentally investigate the motion of spherical Janus particles in viscoelastic fluids with very large relaxation times. In particular, we focus on the behavior of these active particles in presence of walls and obstacles, where very long-range interactions are mediated by the transient flow fields induced by the active motion of the micro-swimmers [4]. We also study inter-particle interactions between micro-swimmers, where the viscoelasticity of the surrounding fluid gives rise to dramatic differences in their collective behavior compared to the motion in Newtonian fluids.

[1] I. Buttinoni, et al., J. Phys.: Cond. Mat. 24, 284129 (2012) [2] B. Qin, et al., Sci. Rep. 5:9190 (2015) [3] A. E. Patteson, et al., Sci. Rep. 5:15761 (2015) [4] Gomez-Solano. , Bechinger, New J. Phys. 17(2015)103032

CPP 12.4 Mon 18:15 Poster B2

Discontinuous thinning behavior in active microrheology of attractive colloids — •Robert Wulfert[1], Udo Seifert[1], and Thomas Speck[2] — [1]II. Institut für Theoretische Physik, Universität Stuttgart, Germany — [2]Institut für Physik, Johannes Gutenberg-Universität Mainz, Germany

Arguably the most exciting phenomena in traditional macrorheology hinge on the non-linear response of complex fluids to external flows. In extreme cases, non-linear flow curves can even comprise discontinuities, as in the paradigmatic example of cornstarch suspensions, which solidify abruptly when exceeding a certain critical strain-rate. Active microrheology (AMR) has established itself rather recently as a complementary approach to infer viscoelastic properties of complex media by driving an embedded colloidal probe and tracing its microscopic trajectory. Although the existence of an exact relation between micro- and macrorheology remains an open issue, AMR has qualitatively reproduced quintessential properties like the thinning and thickening of colloidal soft-matter under flow. Based on the well-established *simple-paradigm* model for AMR, we report on discontinuous force-thinning of colloidal suspensions with attractive long-range interactions: At a critical force, the suspensions microviscosity drops abruptly by about an order of magnitude. By complementing numerical solutions of the pair-Smoluchowski equation with Brownian-dynamics simulations, hysteretical behavior around this critical force is revealed for finite-time force protocols.

CPP 12.5 Mon 18:15 Poster B2

Simultane Bestimmung von Statik, Elastizität und Dynamik an einem Hart-Kugel-Yukawa System — •Sabrina Heidt — Institut für Physik, JGU, D-55099, Mainz, Deutschland

Anhand eines Hart-Kugel-Yukawa Systems wird die simultane Messung von statischen, elastischen und dynamischen Eigenschaften am selben Ensemble mit einer Kombinationslichtstreuanlage (SED) demonstriert. Da die Eigenschaften eines kolloidalen Festkörpers sowohl von den Präparationsbedingungen als auch von der Mikrostruktur der Probe abhängen, eignet sich der vorgestellte Messaufbau besonders zur Vermeidung von transportbedingten Einflüssen auf das Messergebnis. Die im Eigenbau konstruierte SED besteht aus einer statischen, einer dynamischen Lichtstreuanlage und einer Torsionsresonanzspektroskopie zur Schermodulbestimmung kristalliner Proben. Bei dem verwendeten Probensystem aus 80 nm großen Poly-n-Butylacrylamid-co-Polystyrol Kolloiden (PnBAPS80) kann in Abhängigkeit von der Partikelanzahldichte und der Salzkonzentration eine kubisch raumzentrierte Kristallstruktur beobachtet werden. Wobei gleichzeitig das Phasenverhalten und die Kristallisationskinetik wie auch das Schermodul bestimmt werden können. Charakteristische Eigenschaften zur Beschreibung des Systems sind dabei Kolloidgrößen, Kristallitgrößen, Nukleationsraten und Oberflächenspannungen. Durch den Vergleich der präsentierten Ergebnisse der PnBAPS80 mit Literaturdaten anderer kolloidaler Systeme, soll die Leistungsfähigkeit der Anlage verifiziert werden.

CPP 12.6 Mon 18:15 Poster B2

Colloids trapped at fluid interfaces: Capillary-driven dynamics for binary mixtures — •Malte Lütje, Martin Oettel, and Johannes Bleibel — Universität Tübingen, Auf der Morgenstelle 10, 72076 Tübingen

We investigate a binary system of micron-sized colloids that are trapped at liquid-liquid or liquid-gas interfaces. The deformation of the interface due to external forces (i.e. gravity) acting on the colloids gives rise to long-ranged, logarithmic capillary attractions. For a wide range of parameters, these attractions render the system unstable: An initially homogeneous distribution of the colloids on the surface will collapse.

We perform Brownian Dynamics simulations of this system. Interactions between colloidal particles are implemented through a short-ranged repulsion and capillary interactions which dominate the dynamics on different length scales, respectively. We study the dynamical properties and conditions for stability.

As the capillary interactions strongly depend on the radius of the particles, the system and its dynamical phase diagram change if we introduce a second species of smaller colloids. We study the impact of the second species on stability and provide simulation results for the capillary collapse using various sets of parameters.

CPP 12.7 Mon 18:15 Poster B2

The non-equilibrium process of the porous polymer film formation: modeling — •Masoud Amirkhani, Farid Farajollahi, and Othmar Marti — Institut für Experimentelle Physik, Universität Ulm

The breath figure (BF) is a very wide spread method for fabricating porous polymer film. The BF is a simple method, which one uses the condensation of water on an evaporating surface of polymer solution to produce porous film or porous surface. In spite of the simplicity of the BF technique, there is not a physical model that can describe the process. This is due to the complexity of the process, which includes evaporation of the solvent, condensation of water droplets, emerging droplets, mass and heat convection. The combination of the mentioned phenomenon leads to a complicated non-equilibrium process that is very sensitive to the initial system parameters (such as polymer concentration, solvent, the structure of polymer and etc.) and environmental condition (such as temperature, humidity, substrate, airflow speed and etc.). In this work, we describe a possible road map to model the BF and understand the mechanism behind the formation of regular honeycomb structure on the surface of the polymer.

CPP 12.8 Mon 18:15 Poster B2

Influence of Polymer Brush Coated Substrate on the Active Motion of Janus Particles — •Mojdeh Heidari, Stefan Wellert, and Regine von Klitzing — Stranski Laboratorium für Physikalische und Theoritische Chemie, Inst. für Chemie TU Berlin, Straße des 17. Juni, 10623 Berlin, Germany

Au-polystyrene Janus particles demonstrate a thermophoretic induced motion under laser illumination (λ=532 nm). In this study we explore the 2D self-propulsion of Janus particles between two glass substrates. The substrate is functionalized with polymer brushes, as it is hypothesized that the lubricative nature of brushes will reduce the friction coefficient of the substrate which subsequently has a significant influence on the motion of particles close to the substrate. Hence, polymer brushes with varied grafting densities and thicknesses have been synthesized and the corresponding elastic properties have been characterized using colloidal probe AFM. Trajectories of particles are represented under different laser intensities.

CPP 12.9 Mon 18:15 Poster B2

Preparations for DCMIX-3: data analysis from SODI experiments aboard the ISS — •Thomas Triller and Werner Köhler — Physikalisches Institut, Universität Bayreuth, 95440 Bayreuth, Germany

The ISS offers a unique environment for experiments which require microgravity on long timescales. Especially thermodiffusive processes in multicomponent mixtures can be difficult to measure on earth, due to gravitational instabilities. Therefore, a collaboration of several international teams aims to establish within the framework of the ESA DCMIX project a set of reliable benchmark data for selected ternary fluid mixtures measured aboard the ISS. These experiments are done with SODI (Selectable Optical Diagnostics Instrument), a Mach-Zehnder interferometer. The resulting interferograms contain data about the local refractive index, and therefore the local composition of the fluid, across the whole sample cell (also called thermodiffusion cell). The refractive index can be extracted from the interferograms via a Phase Unwrapping method. The DCMIX-3 experiment (the system Water/Ethanol/Triethylene-glycol) was scheduled to fly to the ISS in October 2014. Unfortunately, a catastrophic failure during takeoff destroyed all samples aboard the Orb3 transport. A new flight is planned for April 2016. In the meantime, data from the previous DCMIX-1 experiment (Dodecane/Isobutylbenzene/Tetralin) allow to verify the analysis methods which were implemented for DCMIX-3. These methods make use of the fundamental similarity of all optical experiments involving a thermodiffusion cell.

CPP 12.10 Mon 18:15 Poster B2

Adsorption of silver complexes on gold nanorods - a combined SAXS/SANS study — •Tilo Schmutzler, Torben Schindler, and Tobias Unruh — Friedrich-Alexander-University Erlangen-Nuernberg, Chair for Crystallography and Structural Physics, Staudtstrasse 3, 91058 Erlangen, Germany.

Au nanoparticles have been the subject of widespread research in the last two decades. Therefore, numerous studies dealing with the synthesis leading to exact shape and size control were made. Applications are expected in biological imaging, drug delivery and phototherapeutics.[1]

The synthesis of Au nanorods (AuNRs) includes the addition of AgNO3 as catalytic component. The exact role of the silver species during the rod formation is rather unclear.

Using small angle neutron scattering (SANS) we were able to proof the adsorption of silver complexes on the gold nanorod surface. Thereby the AuNRs were stabilized by the micelle forming surfactant CTAB (Cetyltrimethylammonium bromide). SANS is very sensitive to the existence of these micelles due to the large scattering contrast in D2O whereas small angle X-ray scattering (SAXS) can be used to characterize the AuNRs itself. By the addition of AgNO3 and thiourea into a AuNR solution (1mM CTAB) the release of CTAB micelles was proofed by the increased neutron scattering related to the micelles. So far, we assume that the silver thiourea complexes replace the CTAB molecules at the AuNR facets resulting in the formation of micelles.

[1] C.J. Murphy et. al, J. Phys. Chem B. 2005, 109, 13857-13870.

CPP 12.11 Mon 18:15 Poster B2

Self-Assembly in Dipolar Fluids — •Michela Ronti and Sofia Kantorovich — University of Vienna, Austria

We study low temperature and low density phase behaviour of Dipolar Hard Spheres (DHS) systems. From a theoretical point of view the process of self-assembly is not responsible for a phase transition; this belief was completely reverted by theoretical studies showing that the process of self-assembly is alone capable to induce phase transition(1). On the other hand in the last years it was proved that no sign of critical behaviour is observed, implementing efficient and tailored Monte Carlo algorithms(2). Moreover a theoretical approach based on Density Functional Theory was developed: a series of structural transitions were discovered providing evidence of a hierarchy in the structures on cooling (chains, rings, branched structures)(3). We perform free-energy calculations in order to draw the phase diagram of DHS model. Comparing the numerical results with the theoretical ones shed light on the scenario of temperature induced structural transitions in magnetic nano colloids.

(1) T.Tlusty and S.A.Safran, Science 290 (2000) (2) L.Rovigatti, J.Russo and F.Sciortino, Soft Matter 8 (2012) (3) S.S.Kantorovich, A.O.Ivanov, L.Rovigatti, J.M.Tavares and F.Sciortino, Phys. Chem. Chem. Phys. 17, 16601 (2015)

CPP 12.12 Mon 18:15 Poster B2

Investigations on the kinetics of Liquid-Liquid Phase Separation and dynamic arrest in protein systems — •Stefano Da Vela[1], Fajun Zhang[1], Alessandro Greco[1], Michael Sztucki[2], Zhendong Fu[3], and Frank Schreiber[1] — [1]Institut für Angewandte Physik, Universität Tübingen, 72076 Tübingen — [2]ESRF, Grenoble, France — [3]JCNS, Garching, Germany

Aqueous solutions of bovine γ-globulin in the presence of polyethylene glycol, and of bovine serum albumin in the presence of Yttrium(III),are studied in comparison as two widely differing protein systems, both featuring Liquid-Liquid Phase Separation (LLPS). While in bovine γ-globulin LLPS is determined by an isotropic attractive depletion interaction, in bovine serum albumin LLPS is triggered by Yttrium cations activating a directional "patchy" attractive interaction. Notably, while for γ-globulin the LLPS boundary has an upper critical solution temperature, albumin features a lower critical solution temperature behaviour. The experiments focus on the kinetics of phase separation in samples at high protein volume fraction, driven in the two phase regime by a rapid temperature variation. The development of μm size structures is followed through the stages of the phase separation by state-of-the art time resolved Ultra Small Angle X-Ray Scattering (USAXS) and time resolved Very Small Angle Neutron Scattering (VSANS), complemented by optical microscopy. The time evolution of the characteristic length and the analysis of the scattering profiles allow for a comparison between the two systems and for interpretation of the data relative to the later stages of the phase separation.

CPP 12.13 Mon 18:15 Poster B2

manipulating the assembly of wet-deposited nanocolloids based on in situ GISAXS study — •Peng Zhang[1,2] and Stephan Roth[1] — [1]Deutsches Elektronen-Synchrotron (DESY), Notkestrasse 85, D-22607 Hamburg, Germany — [2]Leibniz Institut für Neue Materialien, Campus D2 2, 66123 Saarbrücken, Germany

The assembly of the nanoparticles and formation of ordered structure during solvent evaporation is strongly influenced by the environmental factors like temperature, surfactant and interface interaction. How to track in situ the kinetic process of nanoparticle assembly is vital for the achievements of structure ordering and optimized functionality. This work reports an in situ study of the assembly process of polystyrene nanocolloids by a smartly designed toolkit, combining the nanocolloidal thin film preparation with air-brush spray deposition and structure analysis with grazing-incidence small angle X-ray scattering (GISAXS). The homogeneously dispersed nanocolloidal thin film is successfully prepared with manipulating the solvent evaporation rate. This is contrast to the generally reported inhomogeneous deposition of particles, e.g., "coffee-ring" like structure. By a qualitative analysis, the inhibition of nanocolloidal aggregation is rationalized by the fact that the necessary diffusion time of most adjacent two nanocolloids is longer than the drying time. This finding is expected to be helpful for the fast fabrication of wet-deposited nanocomposite in thin film.

CPP 12.14 Mon 18:15 Poster B2

The behavior of individual supramolecular ferromagnetic filaments and their suspensions — •Ekaterina Novak[1], Pedro A. Sánchez[2], and Sofia Kantorovich[1,2] — [1]Ural Federal University, Lenin av. 51, Ekaterinburg, 620000, Russia — [2]University of Vienna, Sensengasse 8, 1090, Wien, Austria

Self-assembly in polymer and colloid systems has acquired a special significance nowadays in the context of the development of new smart materials. Here we present the investigation of individual supramolecular ferromagnetic filaments and their suspensions. Filaments are an analogue of a macromolecular polymer, where magnetic nanoparticles are playing a role of predetermined shape monomers. Our research is focused on the setting and analysis of molecular dynamics computer simulation for linear and circle shapes ferromagnetic filaments with dipole hard spheres. We would aim at investigating end-to-end distance, radius of gyration, the self-organization of these filaments, the interaction potentials. Additionally we give a detailed comparison of the behavior of suspension of ferromagnetic filaments and ferrocolloids. These results will form the basis of theoretical models and recommendations on the synthesis of new materials.

CPP 12.15 Mon 18:15 Poster B2

The self-diffusion coefficient in the magnetic fluids — •Alla Dobroserdova[1] and Sofia Kantorovich[1,2] — [1]Ural Federal University, Lenin av. 51, Ekaterinburg, 620000 Russia — [2]University of Vienna, Sensengasse 8, 1090 Vienna, Austria

We present the results on the self-diffusion coefficient in the systems of magnetic dipolar particles. Of course, there were some 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 consider the ferrofluids with chain aggregates of dipolar spheres in the three-dimensional case and with chains and rings in the quasi-two-dimensional one. We can study how the self-diffusion coefficient depends on the system polydispersity, granulometric composition, geometrical constraints and dipolar stregths. In our study, we combine theoretical approach and computer simulation. In theoretical study, we use Density Functional Approach to obtain the chain and ring concentrations. Then we can use them to obtain the self-diffusion coefficients. Also we perform molecular dynamics simulations. We compare theoretical results and data of the computer simulations and we have good agreement.

CPP 12.16 Mon 18:15 Poster B2

Depletion interaction potentials for linear and ring polymer chains in a solution of mesoscopic colloidal particles of big size — •Piotr Kuterba[1] and Zoryana Usatenko[2] — [1]Jagiellonian University, Cracow — [2]Institute of Physics, Cracow University of Technology, Cracow

Investigations of a dilute solution of linear and ring polymer chains immersed in a confined geometry of two mesoscopic colloidal particles of big size and between wall and colloidal particle for different boundary conditions, such as: Dirichlet-Dirichlet, Neumann-Neumann and Dirichlet-Neumann which correspond to the situation of two repulsive walls, two inert walls and for the mixed case of one repulsive and one inert wall were performed. Taking into account the well known polymer - magnet analogy developed by de Gennes and Derjaguin approximation for the case of big colloidal particles the calculations of the correspondent depletion interaction potentials were performed for all above mentioned cases. The obtained results indicate, that introducing the curvature for two surfaces leads to the reducing of the correspondent depletion interaction potentials. The obtained results are in good qualitative agreement with previous theoretical investigations.

CPP 12.17 Mon 18:15 Poster B2

Investigation of the anisotropic magnetic particle systems with moderate and high concentrations — •Elena Pyanzina[1] and Sofia Kantorovich[1,2] — [1]Ural Federal University, Lenin av. 51, Ekaterinburg, 620000, Russia — [2]University of Vienna, Sensengasse 8, Wien, 1090, Austria

Nowadays, anisotropic magnetic particles form the cutting edge of dipolar soft matter research as they correspond completely to the idea of fine tuning and designing new materials with controllable microstructure. As a result, various microproperties can be tuned via changing the particles concentration and the particles properties. In this contribution we focus our attention on the influence of the particles' concentration on the different system properties. The theoretical study and results of computer simulations for microstructure and magnetic, rheological and structural properties of the concentrated systems with different particle shape anisotropy and dipole orientation inside the particle are presented. It was shown that all aforementioned characteristics depend on the particles concentration and particles' parameters. 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 12.18 Mon 18:15 Poster B2

The dynamical phase diagram of the capillary attraction induced collapse of colloidal monolayers at fluid interfaces — Johannes Bleibel[1], Alvaro Domínguez Alvarez[2], •Hans Joachim Schöpe[1], and Martin Oettel[1] — [1]Eberhards Karls Universität Tübingen, Auf der Morgenstelle 10, 72026 Tübingen, Germany — [2]Física Teórica, Universidad de Sevilla, Apdo. 1065, 41080 Sevilla, Spain

We investigate the evolution of a system of colloidal particles, trapped at a fluid interface and interacting via capillary attraction in theory, simulation and experiment. We address the clustering behavior of an initially homogeneous particle distribution and the collapse of a radially symmetric distribution of finite size. It investigated both theoretically by using a perturbative approach inspired by cosmological models and numerically by means of Brownian dynamics (BD) and dynamical density functional theory (DDFT). Furthermore our investigation includes hydrodynamic interactions. We find an accelerated dynamics in the collapse regime. The qualitative phenomenology summarized in the dynamical phase diagram however, remains unchanged. Colloidal particle about 20 micrometer in size trapped at a water decane interface serve as the experimental counterpart. Particles trajectories can easily monitored by bright field microscopy. This allows a direct comparison between theory and experiment.