

CPP 4: Colloidal Fluids

Time: Monday 14:30–16:45

Location: C 264

CPP 4.1 Mon 14:30 C 264

Lateral critical Casimir forces between colloids and chemically patterned substrates — ●FLORIAN SOYKA, CHRISTOPHER HERTLEIN, LAURENT HELDEN, and CLEMENS BECHINGER — Universität Stuttgart, 2. Physikalisches Institut, Pfaffenwaldring 57, 70569 Stuttgart

The confinement of critical fluctuations in binary liquid mixtures near the critical temperature leads to so-called critical Casimir forces. Depending on whether the adsorption preference of the confining walls for one of the two mixture's components is identical or not, the force between the walls is either attractive or repulsive. In our experiments, we investigate the interaction between colloidal particles and a flat wall in a critical water - 2,6 lutidine mixture. As substrates we used glass surfaces which were chemically patterned on a micron-scale leading to a laterally periodic modulation of the substrate's adsorption preference for water and lutidine. When approaching the critical temperature, we observe strong lateral forces acting on the colloidal particles above such substrates which are attributed to critical Casimir forces. Apart from the fundamental importance of such interactions, lateral critical Casimir forces may be also utilized to create ordered arrays of colloidal particles which are important e.g. in photonic applications.

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Charged colloids at water interfaces — ●MARTIN OETTEL¹, ALVARO DOMINGUEZ², DEREK FRYDEL³, and SIEGFRIED DIETRICH³ — ¹Mainz University, Germany — ²University of Seville, Spain — ³Max-Planck-Institute for Metals Research Stuttgart, Germany

The effective interactions of colloids trapped at fluid interfaces exhibit qualitatively new features when compared to the ones in colloidal bulk solutions. Electrostatic interactions which are exponentially screened in ionic solvents become longer-ranged and dipole-like at interfaces between water and a nonpolar medium (usually taken to be air or oil). We show (within Poisson-Boltzmann theory) that charge renormalization makes the effective electrostatic repulsion weakly dependent on the surface charge density on the water side and independent on the salt concentration in the high charge density limit [1]. This is in stark contrast to expectations from linear Debye-Hückel theory which has been used frequently to interpret experimental results. Furthermore, inhomogeneities of colloid surface charge or an anisotropic colloid shape affect the effective interaction only in subleading terms which asymptotically decay faster than the leading dipolar interaction which is isotropic in the interface plane [2].

[1] D. Frydel, S. Dietrich, and M. Oettel, *Phys. Rev. Lett.* **99**, 118302 (2007).

[2] A. Dominguez, D. Frydel, and M. Oettel, arxiv:0706.3977.

CPP 4.3 Mon 15:00 C 264

Computer Simulation of Colloidal Electrophoresis — ●BURKHARD DUENWEG¹, VLADIMIR LOBASKIN^{1,2}, KRISHNAN SEETHALAKSHMY-HARIHARAN¹, and CHRISTIAN HOLM^{1,3} — ¹Max-Planck-Institut fuer Polymerforschung Mainz — ²Physik-Department, TU Muenchen — ³FIAS Frankfurt

We study the motion of a charged colloidal sphere surrounded by solvent, counterions, and salt ions, under the influence of an external electric field. The ions are modeled as particles which interact dissipatively with a lattice Boltzmann background, such that hydrodynamic interactions are taken into account. Similarly, the colloid is modeled as a spherical array of such point particles. Finite concentration values are taken into account by simulating the system in a box with periodic boundary conditions. In terms of dimensionless reduced parameters, the results compare favorably with experimental data. As a complementary approach, we solve the electrokinetic equations by a finite element method.

CPP 4.4 Mon 15:15 C 264

Dynamical heterogeneities in attractive colloids — ●ANNALISA FIERRO¹, EMANUELA DEL GADO², ANTONIO DE CANDIA¹, and ANTONIO CONIGLIO¹ — ¹Dipartimento di Scienze Fisiche, Università di Napoli "Federico II", Italy — ²Polymer Physics, ETH Zürich

Dynamical heterogeneities in glasses are explained in terms of the correlated motion of particles, but their possible connections to any structural feature are still unclear. We study dynamical heterogeneities in

colloidal gelation, where a complex slowing down of the dynamics, directly related to the formation of persistent structures, is observed at different volume fractions. By means of Molecular Dynamics simulations of a model colloidal suspension, we have been able to show that, at low volume fractions, the dynamical heterogeneities are in fact dominated by the clusters of long living bonds[1]. This feature is rather similar to the one observed in irreversible gelation, where the presence of dynamical heterogeneities can be explicitly related to the growing mean cluster size [2]. At higher volume fraction, instead, where crowding of the particles starts to be relevant, dynamical heterogeneities show the typical pattern observed in glassy systems. Interestingly, such behavior can be here well described in terms of a suitable mean cluster size of clusters due to finite lifetime bonds [1].

[1] A. Fierro, E. Del Gado, A. de Candia and A. Coniglio, *cond-mat/0707.4071*. [2] T. Abete, A. de Candia, E. Del Gado, A. Fierro and A. Coniglio, *Phys. Rev. Lett.* **98**, 088301 (2007).

break

CPP 4.5 Mon 15:45 C 264

Scaling laws in the rheology of colloidal dispersions — ●DAVID HAJNAL¹ and MATTHIAS FUCHS² — ¹Institut für Physik, Johannes Gutenberg-Universität Mainz, Staudinger Weg 7, D-55099 Mainz, Germany — ²Fachbereich Physik, Universität Konstanz, D-78457 Konstanz, Germany

We have analyzed the shear flow behavior of dense colloidal dispersions close to the glass transition in the framework of a schematic version of mode-coupling theory (MCT). The schematic model contains the universal aspects of MCT [1] and was successfully applied to describe experimental data for the flow behavior and the linear viscoelasticity of thermosensitive core-shell dispersions [2].

We have derived a universal analytic expression which describes the flow curves quantitatively for small shear rates. This analytic expression provides a deeper understanding of the shapes of the flow curves. For instance, the scaling of the yield stress, the zero-shear limit of the shear stress, and its singular behavior at the glass transition point can easily be obtained by studying special asymptotic limits.

[1] M. Fuchs and M. E. Cates, Schematic models for dynamic yielding of sheared colloidal glasses. *Faraday Discuss.* **123**, 267-286 (2003).

[2] J. J. Crassous, M. Siebenbürger, M. Ballauf, M. Drechsler, D. Hajnal, O. Henrich and M. Fuchs, Shear stresses of colloidal dispersions at the glass transition in equilibrium and in flow. *J. Chem. Phys.*, submitted.

CPP 4.6 Mon 16:00 C 264

Relating structure, dynamics and rheology of soft micellar glasses — ●JÖRG STELLBRINK, BARBARA LONETTI, MARCO LAURATI, LUTZ WILLNER, and DIETER RICHTER — IFF, Forschungszentrum Jülich, D-52425 Jülich

Soft colloids are the link between colloids and polymers, showing some interesting features, which originate from their special hybrid character. Recently, regular star polymers and block copolymer micelles have been independently used to investigate structure, dynamics and rheology on approaching the glass phase as a function of softness.

For kinetically frozen (PEP_m-PEO_n) block copolymer micelles we have shown, that the architecture of the individual micelle can be adjusted between the limits compact sphere like (m≈n) and star-like (m≫n). At the same time the (repulsive) micellar interactions vary from hard sphere like to ultra soft. Micellar structure factors in equilibrium can be described starting from either the hard sphere or the ultra-soft pair potential without adjustable parameters. Therefore PEP-PEO micelles are an excellent model system for soft colloids. Special emphasis will be on non-equilibrium phenomena as i.) jamming transitions in concentrated micellar solutions as observed by dynamic light scattering, pfg-nmr and rheology and ii.) the structural response of ordered/disordered colloidal phases to applied external shear as resolved by in situ neutron scattering techniques (Rheo-SANS).

[1] M. Laurati et al., *Phys. Rev. Letters*, **94**, 195504, 2005.

[2] M. Laurati et al., *Phys. Rev. E*, **76**, 041503, 2007.

CPP 4.7 Mon 16:15 C 264

Structural Rearrangements of Colloidal Gels under Shear — ●LAURATI MARCO¹, PETEKIDIS GEORGE², KOUMAKIS NIKOS², and EGELHAAF STEFAN¹ — ¹Soft Matter Laboratory, HHU Duesseldorf, 40225 Duesseldorf, Germany — ²Polymer and Colloid Group, IESL, FORTH, 71110 Heraklion, Greece

The experimental system investigated in this work are short-ranged attractive colloids obtained from mixtures of PMMA colloidal spheres and PS chains dispersed in cis-decalin. The colloid volume fraction is 40%, the polymer concentration is increased from the fluid to the gel phase. Structural rearrangements of gels under oscillatory shear are investigated by non-linear Rheology and Echo-Diffusing Wave Spectroscopy (Echo-DWS). Rheology allowed us to estimate yield strains and stresses of the gels. Echo-DWS allowed us to determine the characteristic times of the rearrangements and the mean square displacement. The amount and characteristic times of structural rearrangements depend on strain, polymer concentration and frequency of oscillation in a fashion which can be rationalized on the basis of a recently proposed simple model of structural rearrangements driven by breaking of two-particles depletion bonds (Smith,PRE,2007). Additionally, rheological measurements indicate interesting connections with the yielding mechanisms of attractive glasses (Pham,EPL,2006). Two distinct yielding points are observed: one, at strains comparable to the range of the interaction potential, corresponds to the strain at which bonds between particles are broken; the second, at larger strains, corresponds to irreversible rearrangement of the gel structure.

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A local structural mechanism for dynamic arrest — ●PADDY ROYALL¹, STEPHEN WILLIAMS², TAKEHIRO OHTSUKA³, and HAJIME TANAKA³ — ¹School of Chemistry, University of Bristol, Bristol, BS8 1TS, UK — ²Research School of Chemistry, The Australian National University, Canberra, ACT 0200, Australia. — ³Institute of Industrial Science, University of Tokyo, 4-6-1 Komaba, Meguro-ku, Tokyo 153-8505, Japan

The mechanism by which a liquid may become arrested, forming a glass or gel, is a long standing problem of materials science. While possible dynamic mechanisms have received considerable attention, direct experimental evidence of structural mechanisms has proved elusive. The connection between long-lived (energetically) locally favoured structures (LFS), whose geometry may prevent the system relaxing to its equilibrium state, and dynamical arrest dates back at least to F.C. Frank in the 1950s. In a similar spirit, we propose a much broader definition of LFS which we identify with a novel topological method and combine these with experiments at the single particle level on a colloidal liquid-gel transition. The population and lifetime of the LFS is a strong function of (effective) temperature in the ergodic liquid phase, rising sharply approaching dynamical arrest, and indeed the LFS form a percolating network which become the 'arms' of the gel. Due to the LFS, the gel is unable to reach equilibrium, crystal-gas co-existence. Our results form the first direct experimental observation of a link between local structure and dynamical arrest, and open a new perspective on a wide range of metastable materials.