

## CPP 3: Colloids and Nanoparticles I: Structure

Time: Monday 10:00–12:30

Location: H47

CPP 3.1 Mon 10:00 H47

**Structural crossover and connectivity in binary colloidal hard-sphere mixtures** — JÖRG BAUMGARTL<sup>1</sup>, ●ROEL DULLENS<sup>1</sup>, MARJOLEIN DIJKSTRA<sup>2</sup>, ROLAND ROTH<sup>3</sup>, and CLEMENS BECHINGER<sup>1</sup> — <sup>1</sup>2. Physikalisches Institut, Universität Stuttgart, Germany — <sup>2</sup>Soft Condensed Matter Group, Utrecht University, The Netherlands — <sup>3</sup>Max-Planck-Institut für Metallforschung und Institut für Theoretische und Angewandte Physik, Stuttgart, Germany

Already the simplest conceivable multi-component system, i.e. a binary mixture of hard spheres, exhibits an exceedingly rich phenomenology in comparison to single-component systems. Recently, it has been predicted that the phase diagram is divided by a crossover line which distinguishes two regions where the oscillation wavelength of the pair correlation function in the asymptotic limit is either dominated by the diameter of the big spheres or that of the small spheres. Despite the generic character of this structural crossover, this effect has not been observed experimentally. This is the more surprising, because recent calculations demonstrate that the asymptotic regime starts already at intermediate ranges, implying that structural crossover should be visible at relatively small distances. In this work, we use confocal microscopy to investigate the structural crossover in a (high-packing fraction) binary colloidal model system. Furthermore, we address the question as to what the repercussions of the crossover on the structure of a binary fluid are. To this end, we analyze the fluid structure in terms of connectivity based on Delaunay triangulations. This analysis is extended to lower packing fractions using Monte-Carlo simulations.

CPP 3.2 Mon 10:15 H47

**Scattering by Self-Affine Fractals** — ●GERALD JOHANNES SCHNEIDER and DIETMAR GÖRITZ — Institut für Physik, Universität Regensburg, 93040 Regensburg

The structure, i. e. the size and the shape, of colloidsized objects at a length scale of nanometers is of fundamental interest for elementary science and for applications. Due to its statistical relevance and its easy appliance scattering methods are very suitable to study the structure of samples at the nanoscale. However, the information content obtained, strongly relies on models of the structure.

Generally, in order to model colloidal objects, the clusters are considered as spherically symmetric. Although, this assumption simplifies the underlying mathematics, it does not work if external forces acting on the sample and thus the experimental results could not interpreted within standard theories.

In our contribution we introduce a new model, based only on the mathematical framework of self affine fractals, which is able to describe the scattering experiment on both isotropic and anisotropic clusters.

CPP 3.3 Mon 10:30 H47

**Novel crystal phase in suspensions of hard ellipsoids** — ●PATRICK PFLEIDERER and TANJA SCHILLING — Institut für Physik, Johannes Gutenberg-Universität, Staudingerweg 7, 55099 Mainz

Hard ellipsoids serve as a popular model system for granular materials, and colloidal and molecular liquids, solids, and glasses. We present a Monte Carlo simulation study on the crystalline phases of hard ellipsoids of revolution. For aspect ratios  $\geq 3$  we have found a novel crystal, which replaces the previously suggested stretched-fcc phase [D. Frenkel and B. M. Mulder, *Mol. Phys.* **55**, 1171 (1985)]. The unit cell of the new solid contains two ellipsoids with unequal orientations. The lattice is simple monoclinic. The crystal possesses a rheological specialty: The angle of inclination of the lattice,  $\beta$ , is a very soft degree of freedom, while the two right angles are stiff. Further, we have determined that for one particular value of  $\beta$ , the close-packed version of this crystal is a specimen of the family of superdense packings recently reported [A. Donev et al., *Phys. Rev. Lett.* **92**, 255506 (2004)]. Our update of the phase diagram is relevant for studies of nucleation and glassy dynamics of colloidal suspensions of ellipsoids; the rheology may inspire new materials with tailor-made properties.

15 min. break

CPP 3.4 Mon 11:00 H47

**Director Tumbling of Nematic Wormlike Micelles Under**

**Shear: Time-Resolved Rheo-NMR Experiments** — NIKOLAY SINYAVSKY<sup>1</sup>, ISABEL QUIJADA-GARRIDO<sup>2</sup>, and ●CLAUDIA SCHMIDT<sup>3</sup> — <sup>1</sup>Department of Physics, Baltic State Academy, Molodiozhnaya str. 6, 36029 Kaliningrad, Russia — <sup>2</sup>Instituto de Ciencia y Tecnología de Polimeros, Consejo Superior de Investigaciones Científicas, Juan de la Cierva 3, 28006 Madrid, Spain — <sup>3</sup>Department Chemie, Universität Paderborn, Warburger Str. 100, 33098 Paderborn, Germany

Nematic liquid crystals show a complex flow behavior due to the coupling between orientation and flow. Some materials show a stable director orientation in steady shear flow (flow aligning), while for others no stable director orientation exists (tumbling). Director tumbling gives rise to oscillations of shear and normal stresses in rheological experiments and can be detected by optical methods, for example by microscopy or birefringence measurements. We have used deuterium NMR spectroscopy to observe shear-induced director orientations [1,2]. In the lyotropic system cetylpyridinium chloride/hexanol/brine, which forms a nematic phase of wormlike micelles, time-resolved observations of the director orientation by means of deuterium NMR spectroscopy of D<sub>2</sub>O have been possible for the first time. The time-dependence of the director orientations in both shear start-up and flow-reversal experiments will be presented.

[1] D. A. Grabowski, C. Schmidt, *Macromolecules*, **27**, 2632 (1994).

[2] C. Schmidt, in: *Modern Magnetic Resonance*, Vol. 3, Springer, New York, 2006.

CPP 3.5 Mon 11:15 H47

**Precise structure determination of ZnO and CdSe/ZnS core-shell nanoparticles** — ●FRANZISKA NIEDERDRAENK<sup>1</sup>, KNUD SEUFERT<sup>1</sup>, PAWEŁ LUCZAK<sup>1</sup>, CHRISTIAN KUMPF<sup>1</sup>, REINHARD NEDER<sup>2</sup>, and EBERHARD UMBACH<sup>1</sup> — <sup>1</sup>Universität Würzburg, Experimentelle Physik II, Am Hubland, 97074 Würzburg — <sup>2</sup>Universität Würzburg, Mineralogisches Institut, Am Hubland, 97074 Würzburg

In order to obtain an appropriate picture of very small nanoparticles (< 5 nm) and their properties a precise geometric structure determination is essential. X-ray diffraction, in principle, is well suited for this purpose. However, well established methods like powder diffraction including Rietveld refinement are not sufficiently reliable for very small particles, since they are based on solid state approaches. One alternative way is to model the entire nanoparticle and use the Debye formula for calculating its diffraction pattern. As this technique imposes no restrictions on the particle, intrinsic parameters like the particle shape, stacking faults or surface strain can easily be considered. Furthermore, modeling of core-shell particles and consideration of parameter distributions is enabled. Modeling of the nanoparticles, calculation of the diffraction pattern and ensemble averaging are embedded in an evolutionary algorithm for an automated fit procedure.

We present data obtained from ZnO particles and CdSe/ZnS core-shell particles. In order to test the sensitivity of individual parameters many different parameter combinations were considered for the ZnO system. For the core-shell particles we will demonstrate that the consideration of a shell is essential for obtaining proper fit results.

CPP 3.6 Mon 11:30 H47

**Template-Directed Self-Assembly of Nanoparticles** — ●ALEXANDER BÖKER, GÜNTHER JUTZ, NATHALIE MOUGIN, and SERGEJ KOUTOUZOV — Physikalisches Chemie II, Universität Bayreuth, 95440 Bayreuth, Germany

We report on the general concept of nanoparticle self-assembly at templating interfaces. Inorganic cadmium selenide as well as organic particles like ferritin and cow pea mosaic virus (CPMV) are employed as building blocks for three-dimensional assemblies. The self-assembly kinetics is followed by in-situ GISAXS or pendant drop tensiometry depending on the type of interface. The resulting structures are imaged using cross sectional TEM. In addition, several methods (crosslinking, mineralization, etc.) are described to lock the particle assembly into place and construct mechanically robust nanoporous capsules and membranes which are characterized using TEM and SEM.

CPP 3.7 Mon 11:45 H47

**Streuung weicher Röntgenstrahlung an freien Nanopartikeln** — ●HARALD BRESCH<sup>1</sup>, BURKHARD LANGER<sup>2</sup>, BERHARD WASSERMANN<sup>1</sup>, CHRISTINA GRAF<sup>1</sup>, MATHIAS BARTHEL<sup>1</sup>, ROMAN FLESCH<sup>1</sup> und ECK-

HART RÜHL<sup>1</sup> — <sup>1</sup>Institut für Chemie und Biochemie, Freie Universität Berlin, Takustr. 3, 14195 Berlin — <sup>2</sup>Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie, Max-Born-Straße 2A, 12489 Berlin  
 Winkelaufgelöste Lichtstreuung an freien Nanopartikeln wird mittels Synchrotronstrahlung im Bereich weicher Röntgenstrahlung untersucht. Durch einen Aerosolgenerator werden Partikel, die in der flüssigen Phase mit Methoden der Kolloidchemie hergestellt werden, in die Gasphase überführt. Eine aerodynamische Linse erlaubt die Fokussierung des kontinuierlichen Teilchenstrahls im Hochvakuum auf die Synchrotronstrahlung. Mit diesem Ansatz kann Lichtstreuung an freien Nanopartikeln ohne Kontakt zu einem Substrat unter Vermeidung von Strahlenschäden untersucht werden.

Zwei verschiedene Experimente wurden an größenselektierten SiO<sub>2</sub>-Nanopartikeln durchgeführt: Winkelaufgelöste Lichtstreuung im Bereich der Innerschalenanregung, sowie energieaufgelöste Lichtstreuung, wobei der Detektor auf einen festen Winkel gestellt und die Photonenenergie im Bereich der Innerschalenabsorptionskante (Si 2p, O 1s) variiert wurde.

Es lassen sich mit hoher Genauigkeit Größenverteilungen aus den Experimenten ableiten. Der Einfluss des Brechungsindex und der Zusammensetzung der Oberfläche der Nanopartikel wird diskutiert.

CPP 3.8 Mon 12:00 H47

**Smart Multifunctional Hybrid Microgels for Biological Applications** — ●JORGE RUBIO-RETAMA, NIKOLAOS ZAFEIROPOULOS, and MANFRED STAMM — Leibniz-Institute für Polymerforschung e.V. Dresden

In summary, a simple chemical route to synthesize multifunctional smart microgels for bio-applications is discussed in the present study. Magnetic iron oxide nanoparticles were incorporated on the surface of P(NIPAM-AA) microgels rendering materials which are both magnetically and thermally responsive. SEM analysis revealed that the composite microgels have a dense "raspberry" type morphology,

whilst TEM and SAED confirmed the presence of cubic gamma-Fe<sub>2</sub>O<sub>3</sub> nanoparticles mostly on the surface of the microgels. SQUID experiments corroborated the results of SAED showing that indeed the iron oxide nanoparticles are superparamagnetic cubic gamma-Fe<sub>2</sub>O<sub>3</sub>. The incorporation of the iron oxide on the P(NIPAM-AA) microgels shifted their volume transition temperature from 36 to 40 °C, yielding a material that is biocompatible and potentially well suited as carrier for controlled drug release.

CPP 3.9 Mon 12:15 H47

**Miniemulsionen als Basis hochgeordneter Nanopartikel-Ensembles und ihre Anwendung als Ätzmaste** — ●ACHIM MANZKE<sup>1</sup>, FABIAN ENDERLE<sup>1</sup>, CHRISTIAN PFAHLER<sup>1</sup>, ALFRED PLETTL<sup>1</sup>, PAUL ZIEMANN<sup>1</sup>, EYK SCHREIBER<sup>2</sup>, DANIEL CRESPIY<sup>2</sup>, ULRICH ZIENER<sup>2</sup> und KATHARINA LANDFESTER<sup>2</sup> — <sup>1</sup>Institut für Festkörperphysik, Universität Ulm, D-89069 Ulm — <sup>2</sup>Institut für Organische Chemie III, Universität Ulm, D-89069 Ulm

Die Miniemulsionstechnik erlaubt die Herstellung kolloidaler Polystyrol-Partikeln in wässriger Lösung, die mit metallischen Precursoren beladen sind. Wir berichten über Kolloide und Kern-Schale-Kolloide mit Pt-Komplex-Beladung. Auf hydrophile Si/SiO<sub>x</sub>-Substrate aufgetropft, bilden sich hexagonal hochgeordnete Partikel-Monolagen aus. Optimierte Plasma- und Temperprozesse erzeugen Pt-Nanopartikel unter Beibehaltung der ursprünglichen Ordnung. Die Größe der Partikel wird durch die Metallkonzentration im Kolloid bestimmt und konnte bisher zwischen 6 und 13 nm variiert werden. Diese neue Technik besitzt das Potential, die Grenzen der mizellaren Technik [1] hinsichtlich Ordnung und Teilchenabstand deutlich zu übertreffen. Als Anwendung wird gezeigt, wie sich diese Nanopartikel als direkte oder invertierte Ätzmaste in RIE-Prozessen verwenden lassen.

[1] Micellar Nanoreactors - Preparation and Characterization of hexagonally ordered Arrays of Metallic Nanodots, G. Kästle et al. Adv. Funct. Mat. 13, 853 (2003).