

## CPP 59: Complex Fluids and Colloids, Micelles and Vesicles (joint session CPP/DY)

Time: Wednesday 9:30–12:30

Location: ZEU 114

CPP 59.1 Wed 9:30 ZEU 114

**Graphical Magnetogranulometry** — ●INGO REHBERG, REINHARD RICHTER, and STEFAN HARTUNG — Bayreuth University

The dipole strength of magnetic particles in a colloidal suspension can be obtained by a graphical rectification of the magnetization curves based on the inverse Langevin function. The method [1] yields the arithmetic and the harmonic mean of the particle distribution. It has an advantage compared to the fitting of magnetization curves to some appropriate mathematical model: It does not rely on assuming a particular distribution function of the particles.

[1] Measuring magnetic moments of polydisperse ferrofluids utilizing the inverse Langevin function, Ingo Rehberg, Reinhard Richter, Stefan Hartung, and Niklas Lucht, Birgit Hankiewicz, and Thomas Friedrich, Phys. Rev. B 100, 134425 (2019).

CPP 59.2 Wed 9:45 ZEU 114

**Phase Behavior of Charged Magnetic Nanoplatelets** — ●MARGARET ROSENBERG<sup>1</sup> and SOFIA KANTOROVICH<sup>1,2</sup> — <sup>1</sup>Department of Physics, University of Vienna, Austria — <sup>2</sup>Department of Mathematical Physics, Ural Federal University, Russia

Recent decades have seen the emergence of a new branch of science, magnetic soft matter, fueled by the advances in synthesis techniques, which have also made a wide variety of anisotropic magnetic colloidal nanoparticles available. Colloidal anisotropy can be used as an effective control parameter to tune both self-assembly scenarios and thermodynamic, rheological and phase behavior of dipolar (magnetic) soft matter. For instance, magnetic nanoplatelets can form macroscopic ferromagnetic phases at room temperature. Although the phase behavior of a system hard-core platelets is well known, the influence of the magnetic dipole moment and electrostatic repulsion on suspensions of magnetic platelets is not yet fully understood. We use MD simulations to recreate such a system. The colloidal particles are modelled by charged soft spheres, with a central dipole possessing a magnetic moment of a constant length, permanently oriented perpendicular to the platelet surface. In order to investigate the self-assembly and structural properties of the platelets, we vary the amplitude of an applied magnetic field and the magnetic dipole. We analyze at which electrostatic conditions the system exhibits self-assembly or/and field alignment, based on RDFs, structure factors parallel and perpendicular to the field and extensive cluster analysis.

CPP 59.3 Wed 10:00 ZEU 114

**Construction of 1D hollow cube chains as a platform for synthesis of nanoscopic magnetic filaments.** — ●DENIZ MOSTARAC<sup>1</sup>, YAN XIONG<sup>3</sup>, PEDRO A. SANCHEZ<sup>2</sup>, OLEG GANG<sup>3,4</sup>, and SOFIA KANTOROVICH<sup>1,2</sup> — <sup>1</sup>University of Vienna, Vienna, Austria — <sup>2</sup>Ural Federal University, Ekaterinburg, Russia — <sup>3</sup>Columbia University, New York, USA — <sup>4</sup>Brookhaven National Laboratories, New York, USA

Construction of smart materials with sophisticated magnetic response by incorporating magnetic nanoparticles (MNPs) within permanently cross-linked structures, opens up the possibility for synthesis of complex, highly magneto-responsive systems. Assembly using DNA origami frames where the structure building instructions are encoded via DNA sequencing, provides a new perspective on construction of filaments with MNPs. Using programable DNA origami assembly, one can create scaffolds that serve as a blueprints for chain-like conformations of MNPs. Challenge is to produce a DNA based backbone that can be populated with MNPs, which when not subjected to an external magnetic field would in its polymeric properties resemble a real polymer. We present synthesis approach and results of 1D hollow cube chain scaffolds, together with preliminary results of AFM, TEM and SAXS measurements. We present computational models with both explicit and implicit DNA linker modeling, demonstrating the utility of such systems and exploring the influence of the number of DNA linkers between the hollow cubes, and their length, on the polymeric properties of the chained assemblies.

CPP 59.4 Wed 10:15 ZEU 114

**Dynamic Self-assembly of Magnetic Janus Particles** — ●SOFIA KANTOROVICH<sup>1,2</sup>, PEDRO SANCHEZ<sup>1,2</sup>, MAXIMILIAN NEUMANN<sup>3</sup>,SIBYLLE GEMMING<sup>3,4</sup>, and ARTUR ERBE<sup>3</sup> — <sup>1</sup>University of Vienna, Vienna, Austria — <sup>2</sup>Ural Federal University, Ekaterinburg, Russia — <sup>3</sup>Helmholtz-Zentrum Dresden-Rossendorf, Rossendorf, Germany — <sup>4</sup>Technische Universität Chemnitz, Chemnitz, Germany

In this contribution we explain how the interplay between hydrodynamics, magnetic interactions and the frequency of an applied magnetic field affect the structure and the size of clusters formed by magnetic Janus particles. We study silica particles (radius of 2.27 $\mu$ m) with a magnetic thin film coating (of a multilayer stack of Ta(3.0 nm)/Pd(3.0 nm)/[Co(0.28 nm)/Pd(0.9 nm)]<sub>8</sub>/Pd(1.1 nm)) on one hemisphere. Such a layer exhibits perpendicular magnetic anisotropy, i.e., the magnetic flux points out of the film plane [1]. Our previous combined experimental-simulation study showed that if the monolayer of such Janus particles is exposed to a low-frequency magnetic field, one can efficiently control self-assembly letting branched clusters of staggered chains, compact clusters, linear chains, and dispersed single particles to form and reconvert reversibly [2]. In the present contribution, we extend our investigation to high frequency out-of-equilibrium transformations.

[1] M. Albrecht et al., Nat. Mater. 4, 203 (2005). [2] Steinbach et al., PRE 100, 012608 (2019).

CPP 59.5 Wed 10:30 ZEU 114

**Magnetically Functionalized Star Polymers in Equilibrium and under Shear** — ●GERHARD KAHL<sup>1</sup>, DAVID TONEIAN<sup>1</sup>, and CHRISTOS N. LIKOS<sup>2</sup> — <sup>1</sup>Institut für Theoretische Physik, TU Wien — <sup>2</sup>Fakultät für Physik, Universität Wien

Star polymers are macromolecules consisting of a central site, attached to which are a number  $f$  of linear polymer chains, called arms. Depending on the chemical composition of the arms, the polymer stars exhibit intriguing features, both in isolation and in concentrated solution.

We present star polymers with magnetically functionalized end groups as a novel polymeric system whose morphology, self-aggregation and orientation can easily be tuned by exposing these macromolecules simultaneously to an external magnetic field and to shear forces within a channel. Our investigations are based on a specialized simulation technique which faithfully takes into account the hydrodynamic interactions of the surrounding, Newtonian solvent. We find that the combination of magnetic field (including both strength and direction) and shear rate controls the mean number of magnetic clusters, which in turn is largely responsible for the static and dynamic behavior. While some properties are similar to comparable non-magnetic star polymers, others exhibit novel phenomena; examples of the latter include the breakup and reorganization of the clusters beyond a critical shear rate and a strong dependence of the efficiency with which shear rate is translated into whole-body rotations on the direction of the magnetic field.

CPP 59.6 Wed 10:45 ZEU 114

**A biaxial nematic liquid crystal composed of matchbox-symmetric molecules** — ●ROBERT A. SKUTNIK<sup>1</sup>, IMMANUEL S. GEIER<sup>1</sup>, and MARTIN SCHOEN<sup>1,2</sup> — <sup>1</sup>Stranski-Laboratorium für Physikalische und Theoretische Chemie, Technische Universität Berlin, Straße des 17. Juni 115, 10623 Berlin, Germany — <sup>2</sup>Department of Chemical Engineering, Imperial College London, South Kensington Campus, London SW7 2AZ, United Kingdom

By means of Monte Carlo simulations in the isothermal-isobaric ensemble we investigate the structure and phase behaviour of a thermotropic liquid crystal composed of matchbox-symmetric (or board-like) molecules. Besides the isotropic phase the liquid crystal exhibits also uniaxial and biaxial nematic phases. We analyse the orientation distribution function which allows us to distinguish between intrinsic and extrinsic biaxiality. In addition, we study the orientation-dependent correlation functions. In the limit of large intermolecular separations the value of the orientation correlation function corresponds to the uniaxial and biaxial order parameters which are coupled in a complex fashion.

CPP 59.7 Wed 11:00 ZEU 114

**Lyotropic liquid crystals in microfluidic environments** — ●ANSHUL SHARMA and ANUPAM SENGUPTA — Physics of Living Mat-

ter Group, University of Luxembourg, Luxembourg City, Luxembourg

Recent progress in liquid crystal microfluidics has demonstrated how hydrodynamics, in combination with confinement and surface anchoring, can be harnessed to generate tunable flow and topological structures [1, 2]. Lyotropic liquid crystals (LLCs), solutions of disc-shaped amphiphilic mesogens with aromatic core, form linear stacks that aggregate to show nematic or columnar LC phases as a function of temperature or mesogen concentration. LLCs have long been studied for their role in drug and dye manufacturing, and more recently in rapid detection of pathogens. Yet, we lack a fundamental understanding of the response of LLC to micro-scale flows a universal parameter in medical, cellular and industrial settings. With aqueous solution of disodium cromoglycate as our model LLC, we study its behavior under different concentrations and micro-scale flow regimes. Static and flow-induced textures characterized using polarizing microscopy, conoscopy and particle tracking techniques, show emergence of distinctly oriented micro-domains in the flowing LLC. Our results indicate that, for a given surface anchoring, the domain size and lifetime vary with channel geometry and flow speed. Such spontaneous orientational domains could be harnessed to generate locally distinct transport properties within a globally advected material. [1] Sengupta et al., *Liquid Crystals Reviews* 2, 2014. [2] Giomi et al., *PNAS* 114, 2017. [3] Sharma et al. (in prep.)

### 15 min. break

CPP 59.8 Wed 11:30 ZEU 114

**Light driven passive and active motion of colloidal particles** — ●POOJA ARYA, DAVID FELDMANN, and SVETLANA SANTER — University of Potsdam, Potsdam, Germany

We report on how one can manipulate an ensemble of colloidal particles trapped at a solid/liquid interface during irradiation with light of different wavelengths. The colloids are dispersed in an aqueous solution of photosensitive azobenzene containing cationic surfactant, which can photo-isomerize from *trans* to *cis* state under irradiation with light of appropriate wavelength. When focused light is applied, light-driven diffusioosmotic (LDDO) flow is generated at the solid/liquid interface resulting in a passive motion of particles within this flow. Utilizing the same LDDO mechanism one can also induce active motion of porous particles. Here the radially directed flow is generated by and around a single porous colloid when it is irradiated with either UV or blue light. This results in either mutual long-range diffusioosmotic repulsion of the particles or in even self-propelled motion when the colloids are turned into a Janus-like shape. Here, we discuss how to extend of passive and active motion of colloidal particles depends on the irradiation conditions such as wavelengths and intensities of light.

1.\*Feldmann, D.; Maduar S.R.; Santer, M.; Lomadze, N.; Vinogradova O.I.; Santer, S., 6 (2016) 36443

CPP 59.9 Wed 11:45 ZEU 114

**Charge regulation radically modifies electrostatics in membrane stacks** — ●ARGHYA MAJEE<sup>1</sup>, MARKUS BIER<sup>1,2</sup>, RALF BLOSSEY<sup>3</sup>, and RUDOLF PODGORNİK<sup>4</sup> — <sup>1</sup>MPI for Intelligent Systems, Stuttgart & University of Stuttgart, Germany — <sup>2</sup>University of Applied Sciences, Würzburg-Schweinfurt, Germany — <sup>3</sup>University of Lille, CNRS, UMR8576 UGSF, France — <sup>4</sup>CAS & KAVLI Institute of Theoretical Sciences, Beijing

Motivated by biological membrane-containing organelles in plants and photosynthetic bacteria, we study charge regulation in a model membrane stack [1]. Considering (de)protonation as the simplest mechanism of charge equilibration between the membranes and with the bathing environment [2], we uncover a symmetry-broken charge state in the stack with a quasiperiodic effective charge sequence. In the case of a monovalent bathing salt solution, our model predicts complex, inhomogeneous charge equilibria depending on the strength of the (de)protonation reaction, salt concentration, and membrane size. Our results shed light on the basic reorganization mechanism of thylakoid membrane stacks.

References:

[1] A. Majee, M. Bier, R. Blosssey, and R. Podgornik, *Phys. Rev. E* **100**, 050601(R) (2019).

[2] A. Majee, M. Bier, and R. Podgornik, *Soft Matter* **14**, 985 (2018).

CPP 59.10 Wed 12:00 ZEU 114

**Polymer Micelles with Crystalline Cores: self-assembly, molecular exchange kinetics and confinement effects** — NICO KÖNIG<sup>1</sup>, LUTZ WILLNER<sup>2</sup>, and ●REIDAR LUND<sup>1</sup> — <sup>1</sup>Department of Chemistry, University of Oslo, Norway — <sup>2</sup>Institute for Complex Systems ICS, Forschungszentrum Jülich, Germany

Partially crystalline, self-assembling systems with multiple components are omnipresent in nature with living cells as a prominent example. Here we study micelles formed by self-assembly of a series of well-defined n-alkyl-(polyethylene oxide) (C<sub>n</sub>-PEO) polymers in aqueous solutions. By using small-angle X-ray scattering (SAXS), densimetry and differential scanning calorimetry (DSC), we show that the n-alkane exhibit a first-order phase transition, but with reduced melting points compared to bulk. Correlating the structural and thermodynamic data, we found that the melting depression can be accurately described by the Gibbs-Thomson equation. The effect of core crystallinity on the molecular exchange kinetics is investigated using time-resolved small-angle neutron scattering (TR-SANS). We show that the melting transition is cooperative in the confined micellar core, whereas the exchange process is widely decoupled and unimeric in nature. Upon crossing the melting point, a discrete change in the activation energy is found. This suggests that a "local, single-chain melting process" precludes the molecular diffusion out of the micelle during chain exchange

CPP 59.11 Wed 12:15 ZEU 114

**Emulsion destabilisation by squeeze flow** — ●RIANDE DEKKER, ANTOINE DEBLAIS, and DANIEL BONN — Van der Waals-Zeeman Institute, Institute of Physics, University of Amsterdam, Science Park 904, 1098 XH Amsterdam, The Netherlands

There is a large debate on the destabilisation mechanism of emulsions. We present a simple technique using mechanical compression to destabilise oil-in-water emulsions while at the same time confocal microscopy allows to visualise the mechanism directly. Upon compression of the emulsion, the continuous aqueous phase is squeezed out, while the dispersed oil phase progressively deforms from spherical to honeycomb-like shapes. The liquid films that separate the oil droplets are observed to thin and break at a critical oil/water ratio, leading to coalescence events that destabilise the emulsion. The destabilisation occurs like an avalanche propagating through the system. Local rearrangements occur after the first destabilisation due to the first coalescence event. The films participating in the cascade are the finest ones.