CPP 19: Focus: Magnetic Soft Matter I

Time: Tuesday 9:30–12:30 Location: ZEU 222

Invited Talk CPP 19.1 Tue 9:30 ZEU 222
Ferrofluids and their Rheology — •Stefan Odenbach — Chair of Magnetofluiddynamics, TU Dresden, 01062 Dresden

Suspensions of magnetic nanoparticles - commonly called ferrofluids - provide the possibility to control their flow and properties by moderate magnetic fields. After an introduction to ferrofluids, their basic properties and applications (combined with a few small experiments illustrating the magnetic control) the talk will mainly focus on the changes of the rheological properties of ferrofluids in a magnetic field.

Invited Talk CPP 19.2 Tue 10:00 ZEU 222
Field-dependent structure and rheology of magnetic fluids as seen from theory and simulations — •Patrick Ilg — Polymer Physics, ETH Zürich, Department of Materials, CH-8093 Zürich, Switzerland

The interplay between field- and flow-induced structure formation gives raise to very interesting transport properties of magnetic liquids like magnetoviscous and viscoelastic effects [1]. We briefly review some theoretical models of these phenomena, discuss their benefits and limitations and contrast them with simulation approaches [2]. Particular emphasis is laid on the relation between structural and rheological properties as a key issue for improving the current understanding of experimentally observed flow effects. Despite recent progress, there are several experimental findings that still present a challenge for theoretical and/or simulation approaches. Among other things, we mention hexagonal ordering in ferrofluids that might be induced by a delicate balance between steric repulsion and depletion interaction due to excess surfactants [3].

[1] S. Odenbach, J. Phys. Condens. Matter 15 (2003) S1497.
[2] P. Ilg and S. Odenbach, Ferrofluid Structure and Rheology, in "Colloidal Magnetic Fluids", S. Odenbach (Ed.), Springer Lecture Notes in Physics, Vol. 763, 2009.
[3] P. Ilg, Eur. Phys. J. E 26 (2008) 169.

CPP 19.3 Tue 10:30 ZEU 222
Ultra-centrifugation of single-domain magnetite particles and the DeGennes-Pincus approach to ferromagnetic colloids in the dilute regime — •Albert Philipse — Utrecht University, Van 't Hoff laboratory for physical and colloid chemistry, Padualaan 8, 3584 CH, the Netherlands

A fundamental issue for dipolar colloids is the effect of dipole moments sec on thermodynamic and transport phenomena. De Gennes and Pincus argued that the thermodynamics of ferromagnetic colloids, at sufficiently low density, can be simply modeled via an effective isotropic attraction. The present work is motivated by the insight that this very same effective attraction would also determine transport quantities such as sedimentation and diffusion. We have studied sedimentation of stable dispersions of monodisperse magnetic iron-oxide (Fe2O4) colloids, with a dipolar coupling constant tuned by the average particle size. We find that the concentration-dependence of sedimentation rates abruptly changes sign, going from pure hard spheres to even weakly dipolar particles. This marked transition does not follow from the De Gennes-Pincus approach for reasons that will be explained. Our results confirm that effective isotropic attractions are not applicable to explain either thermodynamic or transport properties of magnetic fluids.

15 min. break

Invited Talk CPP 19.4 Tue 11:00 ZEU 222
Mechanical Properties of Uniaxial Magnetic Gels — •Philippe Martinoty — Institut Charles Sadron, Strasbourg, France

Magnetic gels are composite materials made up of magnetic particles embedded in a polymeric matrix. They are called uniaxial when the magnetic particles are oriented in a permanent way in a given direction.

Two questions are crucial for optimizing uniaxial magnetic gels: how they are formed, and what are their responses to a mechanical field? However, these questions remained unstudied, essentially because the conventional rheometers do not allow performing shear measurements under magnetic field. Here we show some results taken during the formation process of a uniaxial magnetic gel and on the formed material with the piezoelectric rheometer we have recently developed.

This apparatus enables to take measurements of the complex shear modulus in a wide frequency range and for very weak applied strains. The kinetics of formation of the gel was followed by placing the cell in the air-gap of an electromagnet, and the organization of the magnetic particles observed by placing the cell under an optical microscope. Two types of uniaxial magnetic gel were studied; an aqueous gel based on a commercial ferrofluid, and an organic gel containing magnetite particles. This presentation is rounded off by a comparison with the mechanical properties of liquid crystal elastomers.

CPP 19.5 Tue 11:30 ZEU 222
Magnetic Capsules and Pickering Emulsions — Andreas Kaiser, Robert Abraham, and •Annette Schmidt — Institut für Organische Chemie und Makromolekulare Chemie, Heinrich-Heine-Universität, Universitätsstr. 1, 40225 Düsseldorf, Germany

In our work we present results on magnetic Pickering emulsions, using superparamagnetic hybrid nanoparticles as susceptible stabilizers. By using the polymer shell of surface grafted iron oxide cores as adaptable solution promoter in a *-solvent, thermoreversible magnetic fluids are obtained that are mixed with water, leading to stable oil in water (o/w) emulsions. Detailed investigations of the involved phase behaviour will be presented together with investigations on the long-term stability of the magnetic capsules towards temperature and in magnetic fields. Magnetic Pickering emulsions are of interest for advanced drug delivery and release systems.

CPP 19.6 Tue 11:45 ZEU 222
Untersuchung der magnetischen Eigenschaften von Nickel Nanostäben in Hydrogelen — •Philipp Bender, Rainer Birringer, Andreas Tschöpe und Andreas Michels — Universität des Saarlandes, Saarbrücken, Deutschland

Nickel Nanostäbe wurden mit Hilfe einer stromgepulsten Abscheidung von Ni in porösen Aluminiumoxidtemplaten synthetisiert und anschließend mit Natronlauge aus der Oxidmatrix herausgelöst. Durch eine Oberflächenmodifikation der Nanostäbe konnten stabile, wasserbasierte Ferrofluide hergestellt werden, welche anschließend bei 50 °C in verflüssigte Glyceringelatine eingerührt wurden. Auf Grund der Thermoreversibilität von Gelatine kommt es bei der Abkühlung des Gelatinesols auf Raumtemperatur zur Vernetzung der Gelatinematrix und somit zu einem Einbau der Nickel Nanostäbe in das Gelnetzwerk (isotrope Ferrogele). Zusätzlich ist es möglich durch Anlegen eines äußeren Feldes während der Vernetzung die Nanostäbe auszurichten und dadurch Hydrogele mit einer ausgezeichneten Vorzugsrichtung zu erzeugen (anisotrope Ferrogele).

In der vorliegenden Arbeit wurde mit Hilfe von Magnetisierungsmessungen die Kopplung der magnetischen Eigenschaften der Nanostäbe mit den elastischen Eigenschaften der Gelatinematrix sowohl in isotropen als auch anisotropen Ferrogelen untersucht. Desweiteren wurden temperaturabhängige Hysteresemessungen sowie field- und zero-field-cooling, field-warming (FC/FW, bzw. ZFC/FW) Messungen durchgeführt um die Temperaturabhängigkeit der magneto-elastischen Kopplung innerhalb der Ferrogele zu charakterisieren.

CPP 19.7 Tue 12:00 ZEU 222
Particle co-operated block copolymer self-assembly — •Mottakin M. Abul Kashem[1], Jan Perlich[1], Alexander Diethert[1], Weinan Wang[1], Mine Memesa[2], Jochen S. Gutmann[2], Eva Majkova[3], Ignác Capek[4], Stephan V. Roth[5], and Müller-Buschbaum Peter[1] — [1]TU München, Physik-Department LS E13, James-Franck-Str.1, Garching, Germany — [2]MPI for Polymer Research, Ackermannweg 10, 55128 Mainz, Germany — [3]Inst. of Phys. SAS, Dúbravská 9, SK 84511 Bratislava, Slovakia — [4]Polymer Inst., SAS, Dúbravská 9, SK 84236 Bratislava, Slovakia — [5]HASYLAB at DESY, Notkestr. 85, 22603 Hamburg, Germany

We have investigated the role of nanoparticles in particle co-operated self-assembly process and the domain orientation in asymmetric di-block copolymer films in order to create ordered array of magnetic nanoparticles [1-2]. Thin films are prepared from solutions of polystyrene-block-polymethylmethacrylate (PS-b-PMMA) containing varying amount of iron oxide nanoparticles. During annealing, the nanoparticles distribute themselves inside the cylindrical domains of

PMMA, which increases the diameters of cylindrical domains and cylinder-to-cylinder distances. Moreover, the nanoparticles contribute to the perpendicular orientation of PMMA domains through balancing the interfacial energy difference between PS and PMMA blocks. The investigations have been carried out by using AFM and SEM, x-ray reflectivity and GISAXS.

1.Abul Kashem, et al. Macromolecules 2007, 40, 5075. 2.Abul Kashem, et al. Macromolecules 2008, 41, 2186.

CPP 19.8 Tue 12:15 ZEU 222

Surface Instabilities and Magnetic Soft Matter — •Christian Gollwitzer[1], Marina Krekhova[2], Günter Lattermann[2], Ingo Rehberg[1], and Reinhard Richter[1] — [1]Experimentalphysik V, Universität Bayreuth, 95440 Bayreuth, Germany — [2]Makromolekulare Chemie I, Universität Bayreuth, 95440 Bayreuth, Germany

Thermoreversible ferrogels are the most recent incarnation of magnetic soft matter [1]. There mechanical deformation in homogeneous magnetic fields has been studied for the case of a sphere in [2]. We report now on the formation of surface instabilities in a layer of thermoreversible ferrogel when exposed to a vertical magnetic field. Both static and time dependent magnetic fields are employed. Under variations of temperature, the viscoelastic properties of our soft magnetic matter can be tuned. Stress relaxation experiments unveil a critical scaling behaviour of the relaxation time, as predicted in [3]. The resulting magnetic threshold for the formation of Rosensweig-cusps is measured for different temperatures, and compared with theoretical predictions [4]. Details can be found in the preprint [5].

[1] G. Lattermann and M. Krekhova, *Macromol. Rapid Commun.*, 2006, **27**, 1373–1379
[2] C. Gollwitzer, A. Turanov, M. Krekhova, G. Lattermann, I. Rehberg, and R. Richter, *J. Chem. Phys.*, 2008, **128**, 164709.
[3] P. G. de Gennes, *Macromolecules*, 2002, **35**, 3785–3786.
[4] S. Bohlius, H. Brand, H. Pleiner, and M. Gels, *Z. Phys. Chem*, 2006, **220**, 97–104.
[5] http://arxiv.org/abs/0811.1526