CPP 12: POSTERS Magnetic Soft Matter

Time: Tuesday 14:00–16:30 Location: P3

CPP 12.1 Tue 14:00 P3

Interaction between rotating anisotropic paramagnetic doublets at Oil-Water Interface and in the bulk — •Nebojša Ćasić[1], Pietro Tierno[2], and Thomas Fischer[3] — [1]Institut für Experimentalphysik V, Universität Bayreuth, Bayreuth, Germany — [2]Department de Quimica Fisica, Universitat de Barcelona, Barcelona, Spain — [3]Institut für Experimentalphysik V, Universität Bayreuth, Bayreuth, Germany

Optical microscopy is employed for studying hydrodynamic interactions between rotating anisotropic paramagnetic doublets in the bulk and at the oil-water interface. Anisotropic rotors are formed by linking two paramagnetic colloidal particles with two complementary sequences of single stranded DNA. An external precessing magnetic field induces rotation of the doublet.

CPP 12.2 Tue 14:00 P3

Experiments on dynamics of transients in magnetic colloids — •Dmitry Borin and Stefan Odenbach — Technische Universität Dresden, Institute of Fluid Mechanics, Chair of Magnetofluiddynamics, 01062 Dresden, Germany

The detailed understanding of the internal physical nature of slow relaxation phenomena in disordered materials is still not reached. Therefore the study of relaxation phenomena in magnetic suspensions of single-domain Brownian nanoparticles (ferrofluids) is highly interesting for the general theory of dynamical phenomena in complex and soft systems. As it is known from previous studies, some ferrofluids show a long time reaction to a stepwise change of shear stress at constant magnetic field strength, as well as to a stepwise change of magnetic field strength at constant shear rate. The goal of this work was to shed some light on this temporal behavior. We performed experiments on magnetite based ferrofluids with a small particle-particle interaction parameter, as well as on cobalt based ferrofluids, containing particles which are large enough to form chain-like structures. The obtained results are compared with measurements performed on magnetorheologial suspensions consisting of non Brownian particles. This comparison enables a study of the fundamental role of the Brownian effects for the macroscopic rheological properties of such suspensions.

CPP 12.3 Tue 14:00 P3

Dynamics of rolling ferrofluidic drops propelled by a rotating magnetic field — •Fabian Rittweg, Reinhard Richter, and Ingo Rehberg — Experimentalphysik V, Universität Bayreuth, D-95440 Bayreuth

We report on the controlled transport of drops of magnetic liquid, which are swimming on top of a non-magnetic liquid layer. A magnetic field which is rotating in a vertical plane creates a torque on the drop. Due to surface stresses within the immiscible liquid beneath, the drop is propelled forward. We measure the drop speed for different field amplitudes, field frequencies and drop volumes. The results are compared with simplifying theoretical models proposed by V. Sterr, *et al.*, New J. Phys., 10, 063029 (2008), where also our first measurements can be found.

CPP 12.4 Tue 14:00 P3

Cross-calibration of MRX and micro-CT for analysis of tissue samples after magnetic drug targeting — •Helene Rahn[1], Ingrid Hilger[2], Lutz Trahms[3], and Stefan Odenbach[1] — [1]Institute of Fluid Mechanics, TU Dresden — [2]University Hospital Jena — [3]Physikalisch-Technische Bundesanstalt, Berlin

Magnetic Drug Targeting (MDT) and Magnetic Hyperthermia, using the strong influence of a magnetic field on ferrofluids, are being considered as local cancer treatments with the aim of reducing the side effects occuring during conventional cancer methods. The success of MDT and MHT depends on the correct distribution of the iron oxide nanoparticles within the tumour. This distribution can be analyzed by the non-invasive methods X-Ray microcomputed tomography (micro-CT) and magnetorelaxometry (MRX). To enable semi-quantitative analysis of these samples, a calibration with phantoms consisting of magnetic nanoparticles embedded in agarose-gel has been performed. The iron concentrations have been determined by MRX and vary from 2,88 E-5 mg/ml for a dilution of 1:300000 to 8,51 mg/ml for a dilution of 1:3. The same samples have been analysed by micro-CT and the minimum concentrations of these iron particles that can be detected by both methods have been determined and represented in a calibration curve. Based on this cross-calibration of micro-CT and MRX any biological sample with an iron oxide concentration within the range from 0.864 mg/ml to 8.64 mg/ml can be analysed by both methods. From both techniques, that is, the concentration and the volume distribution of these nanoparticles will be presented.

CPP 12.5 Tue 14:00 P3

Column formation in magnetic granular matter — •Sebastian Lehmann, Ingo Rehberg, Thomas Fischer, and Reinhard Richter — Experimentalphysik V, Universität Bayreuth,

Inspired by the Rosensweig Instability occuring in magnetic fluids, we are investigating a related pattern forming mechanism in magnetic granular matter. A monolayer of magnetizable spheres rearranges itself to columns of spheres under increase of the magnetic field. The latter is created by a Helmholtz pair of coils. We measure the heights of the columns as a function of the applied field and compare it with different models, using the energy of the different configurations as a basis of the computation.

CPP 12.6 Tue 14:00 P3

COLLOIDAL MICROMOTORS — •Larysa Baraban, Christian Kreidler, Denys Makarov, Paul Leiderer, and Artur Erbe — Department of Physics, University of Konstanz, Universitätstrasse 10, Konstanz, D-78457, Germany

The interest in investigations of colloidal systems has been growing during the last years. This is mainly related to the flexibility of properties of the colloidal particles which allows their usage in life science, for instance, as drug delivery vehicles. Here we demonstrate that the system of magnetic capped colloids is the appropriate tool to realize the concept of the synthetic nano- and micro-engines. A long -range controlled movement of capped colloids, which is induced by a local catalytic reaction, is demonstrated. The application of a weak homogeneous magnetic field blocks processes of rotational diffusion, causing random changes of the direction of the driving force; it thus allows achieving directed motion of the particle on long scales. Therefore, these fully controlled artificial motors can be further developed to be used, for example, for the targeted delivery of micro-objects to the relevant places.

CPP 12.7 Tue 14:00 P3

Time-resolved X-ray microscopy of nanoparticle aggregates under oscillatory shear — •Günter K. Auernhammer[1], Kai Fauth[2,3], Jinyu Zhao[1], Markus Weigand[2], and Doris Vollmer[1] — [1]Max-Planck-Insitut für Polymerforschung, Ackermannweg 10, 55128 Mainz — [2]Max-Planck-Insitut für Metallforschung, Heisenbergstrasse 3,70569 Stuttgart — [3]Experimentelle Physik 4, Physikalisches Institut, Am Hubland, 97074 Würzburg

X-ray microscopy is an imaging technique which allows for a spatial resolution below 35 nm. We used it to investigate shear-induced structural dynamics by inserting a piezo actuator-driven shear cell into the focal plane of a scanning transmission x-ray microscope (STXM). We investigate shear-induced reorganization of aggregates of 50 nm sized magnetite particles embedded in a polymer melt. Depending on the amplitude of the applied oscillatory shear, either the aggregates strongly move and reorganize (large amplitudes) or just slightly deform (low amplitudes). We correlated the deformations of the aggregates with their structure (as visible in the STXM) and the amplitude of the applied shear. Comparison of our results to experiments with nonmagnetic colloids is made.

CPP 12.8 Tue 14:00 P3

Structure formation in ferrofluid monolayers: theory and computer simulations — •Christian Holm[1,2,3], Juan Cerda[1,2], and Sofia Kantorovich[3,4] — [1]Universität Stuttgart. Institut für Computerphysik, 70569 Stuttgart, Germany — [2]FIAS,Goethe-University Frankfurt, Germany — [3]MPI for Polymer Research, Mainz, Germany — [4]Department of Mathematical Physics, Urals State University, Ekaterinburg, Russia

Ferrofluid particles are known to self-assemble into a variety of magnetic equilibrium structures which depend on several factors such as:

system geometry, magnetic interactions, particle polidispersity, presence or absence of external fields, etc. The phase behaviour and microstructure of ferrofluid systems in reduced dimensions is not necessarilly equivalent to that of 3D systems. In order to investigate the peculiarities brought by the 2D geometry into the aggregation processes in ferrofluids, a combination of density functional theory, and molecular dynamics (MD) simulations is presented. Long-range dipolar interactions in our monolayer simulations are computed using a recently developed dipolar-P3M-layer correction algorithm. In comparison to the traditional Ewald sum methods, this approach allows to handle larger systems. The mircrostructure formation and the behaviour of monodisperse and bidisperse ferrofluid monolayers are studied thoroughly, and a comparison between numerical simulations and DFT is presented.

CPP 12.9 Tue 14:00 P3

Effects of magnetic fields on ferrofluids in a Taylor Couette System — •Reindl Matthias — George Bähr Str. 3, 01062 Dresden

The magnetization of a ferrofluid in rest is describable by equations for the equilibrium magnetization. A flowing ferrofluid, yielding, due to shear gradients, a vorticity with directions perpendicular to a magnetic field, turns the magnetic dipoles out of magnetic field direction. The magnetization is now also dependent on the flow field. Hence, equations to describe the magnetization out of equilibrium are necessary. Since the different models for this purpose differ more or less, the adequate one has yet to be distinguished. By comparing experimental and simulation data of a model system, this goal might get achieved. As a model system, a Taylor-Couette apparatus with the fluid cell exposed to magnetic fields was chosen. Measurement data obtained by capturing the transition from circular Couette flow to Taylor vortex flow at different magnetic fields is compared to simulation data and presented.

CPP 12.10 Tue 14:00 P3

Thermomagnetic convection influenced by a parametric modulated magnetic field — •Harald Engler and Stefan Odenbach — Lehrstuhl für Magnetofluiddynamik, Technische Universität Dresden, 01062 Dresden

Previous theoretical investigations on thermal convection have shown that the behaviour of the onset of convection where the characteristic of the heat flux changes from a conductive to a convective state depends on the frequency of the driving force. The implementation of an experimental setup to review the theoretical predictions fails due to the immense technical effort to provide a time-modulated driving force. A way out of these technical difficulties affords the fact that by applying an external magnetic field a magnetic force in ferrofluids arises which is able to drive a convective flow. The external magnetic field can thus be arranged to provide a time-dependent progress of the field strength leading to a time-modulated magnetic force. This kind of convection which is driven by the magnetic force is called thermomagnetic convection. The experiments have shown a shift in the onset of convection that means for certain ranges of the frequencies of the magnetic force the convection is stabilized or destabilized. The results of the experimental investigations as well as the experimental setup to indicate the onset of convection will be presented at the talk.

CPP 12.11 Tue 14:00 P3

Structure factor of the ferrofluid with chain aggregates. — •Elena Pyanzina[1], Sofia Kantorovich[1,2], Juan Cerda[2], and Christian Holm[2] — [1]Ural State University, Ekaterinburg, Russia — [2]University of Stuttgart, Stuttgart, Germany

We analyze the structure factor of a ferrofluid with strong interparticle magnetic dipole-dipole interaction. Results on bidisperse model systems in the absence of an external magnetic field are presented. The theoretical calculations are based on the explicit construction of radial distribution functions from the chain distributions obtained via density functional minimization. Data obtained via molecular dynamics simulations for the same model are provided for the verification of our analytical calculations. The results of our study are compared to the experimental data from [L.M. Pop, S. Odenbach, J. Phys.: Cond. Mat. (2006)].

CPP 12.12 Tue 14:00 P3

Traveling-stripe forcing of a ferrofluid — •Thomas Friedrich, Reinhard Richter, and Ingo Rehberg — Experimentalphysik V, Universität Bayreuth, D-95440 Bayreuth

Transport of a ferrofluid has been achieved by rotating magnetic fields [1]. In contrast, we apply a smooth periodic spatiotemporal modulation of the magnetic induction to a shallow layer of magnetic liquid. In the subcritical regime of the Rosensweig instability [2], driven surface waves [3] occur. Theese surface waves cause a transport of ferrofluid, which is analysed by means of radioscopy. For supercritical magnetic field strengths, a frequency dependent pattern formation can be observed. The effect of locomotion and the structural transitions in the subcritical and the supercritical regime are studied. The results are compared to Refs.[4,5].

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[2] M. D. Cowley and R. E. Rosensweig, J. Fluid Mech. **30** 671 (1967)
[3] A. Beetz, C. Gollwitzer, R. Richter, I. Rehberg, J. Phys.: Condens. Matter **20** 204109 (2008)
[4] S. Rüdiger, E. M. Nicola, J. Casademunt, L. Kramer, Physics Reports **447** 73-111 (2007)
[5] K. Zimmermann, I. Zeidis, V.A. Naletova, V.A. Turkov, J. Magn. Magn. Mater. **268** 227 (2004)

CPP 12.13 Tue 14:00 P3

Locoregional Polymerization from Nano-Object Surfaces: A Kinetic Study — Celin Gürler[1], Alex Bian[2], and •Annette Schmidt[1] — [1]Institut für Organische Chemie und Makromolekulare Chemie, Heinrich-Heine-Universität, Universitätsstr. 1, 40225 Düsseldorf, Germany — [2]Department of Chemistry, University of Calgary, Alberta, Canada

The possibility to activate a chemical reaction locally in a confined environment by selective heating is of great potential and interest for the design of complex nanostructures. Our approach is to use the ability of dipolar nanoparticles to transform electromagnetic energy into thermal energy in order to activate a (surface-initiated) polymerization process predominantly on the particle-medium interface.[1] The particles investigated are cobalt-based nanoparticles, known to undergo heat dissipation by Brownian rotation upon irradiation in an AC field in the kHz range. In our work we directly compare kinetic data obtained by magnetic heating and conventional heating. Both data sets indicate a reaction rate of pseudo first order, while a significant faster conversion is obtained by using magnetic heating when compared to conventional heating at the same bulk temperature. We found significant differences in the architectures of the particles that suggest an impact of the heating mode on the morphology of the resulting materials and a reasonable control on the shell thickness by the field parameters in magnetically heated experiments.