

## CPP 35: Poster: Micro- and Nanofluidics

Time: Wednesday 17:00–19:00

Location: P2

CPP 35.1 Wed 17:00 P2

**Lattice Boltzmann simulations of cytoplasmic streaming** — ●KATRIN WOLFF, DAVIDE MARENUZZO, and MIKE CATES — Institute for Condensed Matter and Complex Systems, University of Edinburgh, UK

We model the cytoplasm's streaming motion in giant algae cells using lattice Boltzmann simulations. The fluid motion is driven by myosin motors carrying vesicles and crawling along actin filaments which are attached to the outer part of the cytoplasm. We address how the high speeds observed in experiments can be transmitted through the cytoplasm by assuming a layer of lower viscosity at the outer wall of the simulated compartment. The bulk cytoplasm is crowded with cell organelles but modelled as a simple fluid of high viscosity appropriate for the shear experienced. The motivation behind the low-viscosity layer is the assumption that those cell contents populating the cytoplasm do not reach up to the cell wall resulting in a more dilute solution close to the wall. The low-viscosity layer is not simulated itself but incorporated into a partial slip boundary condition. We derive an expression for a single-parameter boundary condition based on the relative viscosities of the bulk cytoplasm and the thin layer close to the wall and the layer's thickness.

CPP 35.2 Wed 17:00 P2

**Application of a lattice Boltzmann model for amphiphilic fluid mixtures** — SEBASTIAN SCHMIESCHEK<sup>1</sup> and ●JENS HARTING<sup>2</sup> — <sup>1</sup>ICP, Uni Stuttgart, Pfaffenwaldring 27, 70569 Stuttgart, Germany — <sup>2</sup>MTP, Dept Appl Phys, TU Eindhoven, P.O.B. 513, 5600MB Eindhoven, The Netherlands

Due to its inherent mesoscopic character and ease of implementation and parallelisation, the lattice Boltzmann method (LBM) has become a popular model for simulations of soft matter systems.

Earlier, a multi relaxation time lattice Boltzmann model for amphiphilic fluid mixtures was presented. This model allows to resolve some of the problems existing in the broadly used single relaxation time schemes. The code allows the simulation of binary and ternary multicomponent systems, containing (im)miscible and optionally amphiphilic fluid species.

Results of the investigation of applicability of the model to simulate fluid mixtures in porous media are presented. Interesting physical properties include diffusivity and relative permeabilities.

CPP 35.3 Wed 17:00 P2

**Molecular Orientational Order Phenomena in Boundary Layers observed in Nanopore Flows** — ●SIMON GRUENER<sup>1</sup>, DOMINIK GERSTNER<sup>1</sup>, YANNICK D. KERVRAN<sup>2</sup>, and PATRICK HUBER<sup>1</sup> — <sup>1</sup>Experimental Physics, Saarland University, Saarbruecken, Germany — <sup>2</sup>Université de Rennes 1, Rennes, France

We present measurements on the spontaneous as well as the externally induced invasion of liquids into silica monoliths (porous Vycor) permeated by a tortuous pore network with radii on the scale of a few nanometers only. The dynamics are recorded upon varying the complexity of the liquid's building blocks (mostly chain-like hydrocarbons). For the homologous series of non-polar alkanes we find boundary layers (i.e. immobile layers at the silica pore walls) composed of flat lying molecules with the thickness of one molecular diameter. However, switching to the series of polar 1-alcohols we detect a rearrangement of the molecular order in favor of pinned molecules being oriented perpendicular to the pore walls. This finding demonstrates the tendency to pair the polar hydroxyl groups of both the alcohol and the silica pore walls in order to minimize the system's overall energy. The thickness of the boundary layer suggests a slanting of the molecules possibly due to the viscous drag exerted by the liquid flow in the pore center. This work has been supported within the DFG priority program 1164, Nano- & Microfluidics (Grant No. Hu 850/2).

CPP 35.4 Wed 17:00 P2

**Forced Imbibitions Experiments in 2D Porous Media.** — ●MICHAEL JUNG<sup>1,2</sup>, STEFAN HERMINGHAUS<sup>2</sup>, and RALF SEEMANN<sup>1,2</sup> — <sup>1</sup>Universität des Saarlandes, Saarbrücken, Germany — <sup>2</sup>Max Planck-Institute for Dynamics and Self-Organization, Göttingen, Germany

As a simple model for forced liquid imbibitions into porous media, we

study two-dimensional flow experiments in microfluidic devices. The devices and the porous structure are fabricated from oil-resistant UV-curable glue using a soft-lithography technique. These devices were first saturated with oil of different viscosities and densities (silicon oils or alkanes). The oil was then displaced by flushing water of different flow rates. To precisely distinguish between the oily and the aqueous phase we add a dye to the aqueous phase. We observe the global and local dynamic behavior of liquid front and the remaining oil saturation using high speed microscopy. The effect of various additional parameters, such as surface tension and the size and geometry of the pore space on the position and the roughening of the liquid front as well as the remaining fraction of trapped oil was investigated in detail.

CPP 35.5 Wed 17:00 P2

**Characterising residual oil saturation using X-ray micro Tomography** — ●HAGEN SCHOLL<sup>1</sup>, KAMALJIT SINGH<sup>1,2</sup>, MARCO DI MICHIEL<sup>3</sup>, MARIO SCHEEL<sup>3</sup>, and RALF SEEMANN<sup>1,2</sup> — <sup>1</sup>Saarland University, Experimental Physics, D-66041 Saarbrücken, Germany — <sup>2</sup>MPI for Dynamics and Self-Organization, D-37073 Göttingen, Germany — <sup>3</sup>European Synchrotron Radiation Facility, BP 220, F-38043 Grenoble, France

We examined water imbibition in an initially oil saturated porous medium using X-ray micro tomography at the European Synchrotron Radiation Facility (ESRF, ID15). Our aim is to characterise the residual oil saturation after a complete water flood under various flow conditions. As a porous medium with well defined pore space and wettability, we use a pile of monodisperse microspheres. Glass and basalt spheres were used for water wet and oil wet systems, respectively. To easily distinguish the aqueous phase from the oily phase, we add a small percentage of ZnI<sub>2</sub> to the aqueous phase. After a complete water flood, the final residual oil distribution was characterised for oil globules/blobs (ganglia) type, size and spatial distribution. It was observed that the final oil saturation in a water wet system was higher due to significant by-passing of several oil pore pockets, and it seems that the flow rates do not play a significant role in the residual oil saturation.

CPP 35.6 Wed 17:00 P2

**Effects of concentration-dependent wettability on the statics and dynamics of droplets of mixtures and suspensions** — ●DEISLAVA V TODOROVA and UWE THIELE — School of Mathematics, Loughborough University, Leicestershire, LE11 3TU, United Kingdom

We discuss the behaviour of small drops of non-volatile liquid mixtures, colloidal suspensions and polymer solutions on a solid substrate. A hydrodynamic long-wave model is developed to analyze static and moving contact lines in the case of partially wetting liquids that show a concentration-dependent wettability. Thereby, Hamaker constants for mixtures are obtained employing homogenization techniques [1].

The model is used to study static drop profiles, in particular, the change of the equilibrium contact angle with mean solute concentration. Following this, we focus on sliding drops and look at the change of dynamic contact angles and drop profiles with concentration for the cases of constant and concentration-dependent viscosity. Individual drop and concentration profiles and characteristics of solution families are obtained employing numerical continuation and time simulation techniques [2].

[1] G. A. Niklasson, C. G. Granqvist, O. Hunderi, Appl. Optics 20, 26-30 (1981); D. Todorova et al., J. Optoelectron. Adv. Mater. 11, 1296-1299 (2009)

[2] E. Doedel, H.B. Keller, J.P. Kernevez, Int. J. Bifurcation Chaos 1, 493-520 (1991); P. Beltrame, U. Thiele, SIAM J. Appl. Dyn. Syst. 9, 484-518 (2010)

We acknowledge support by the EU (PITN-GA-2008-214919).

CPP 35.7 Wed 17:00 P2

**Dynamic Wetting of Polyisoprene Melts with Different End Groups** — ●ELMAR BONACCURSO<sup>1</sup>, CHUANJUN LIU<sup>1,2</sup>, MORDECHAI SOKULER<sup>1,2</sup>, GÜNTER AUERNHAMMER<sup>2</sup>, and HANS-JÜRGEN BUTT<sup>2</sup> — <sup>1</sup>Center of Smart Interfaces, TU-Darmstadt, Germany — <sup>2</sup>Max Planck Institute for Polymer Research, Mainz, Germany

We investigate the spreading of drops of polyisoprene melts with different end groups, methyl (PI-CH<sub>3</sub>), hydroxyl (PI-OH), and carboxyl

(PI-COOH), on hydrophilic silicon surfaces. The three polymers have the same backbone and contour length. The only difference lies in the end group. We show its influence on the dynamics of wetting. Our experimental results indicate, e.g., that spreading of PI-OH and PI-COOH is slowed down as compared to PI-CH<sub>3</sub>.

Lower contact angles are attained if the end groups strongly bind to the solid surface. Hence, the wetting capability of the polymer melt could be improved by non-covalent interfacial interactions via its end groups. The hydrodynamic model[1] applied to our measurements gives a good fit to the experimental data, but does not yield reasonable values for the apparent slip length. This suggests that additional dissipative processes are at work within the three-phase zone, which may not be omitted from the overall description. Molecular Kinetic Theory[2] (MKT) analysis indicates that strong binding of molecules to surface leads to longer relaxation times, thus to a slower spreading process [3].

[1] O.V. Voinov, J. Colloid Interface Sci. 226, 22 (2000) [2] T.D. Blake, J. M. Haynes, J. Colloid Interface Sci. 30, 421 (1969). [3] C.J. Liu et al., Langmuir, 26, 2544 (2010)

CPP 35.8 Wed 17:00 P2

**Liquid Morphologies in granulates with various wettability** — ●MARC SCHABER<sup>1</sup>, SOMNATH KARMAKAR<sup>1</sup>, MARIO SCHEEL<sup>3</sup>, MARTIN BRINKMANN<sup>2</sup>, MARCO DI MICHIEL<sup>3</sup>, and RALF SEEMANN<sup>1,2</sup> — <sup>1</sup>Experimental Physics, Saarland University, D-66041 Saarbrücken — <sup>2</sup>MPI for Dynamics and Self-Organisation, Bunsenstr. 10, D-37073 Göttingen — <sup>3</sup>European Synchrotron Radiation Facility, 6 rue Jules Horowitz, F-38000 Grenoble

Adding liquid to dry granulates causes the formation of a network of capillary bridges and complex liquid structures inside the granulates and typically a stiffening of the granulate is observed. Depending on wettability of the granulate different liquid structures are formed and lead to different mechanical properties. By means of computed X-ray tomography we explore the static three dimensional packing geometry of granulates and the emerging liquid distribution within them. As granulates we use glass and basalt microspheres and mixtures of both. The glass microspheres have a low contact and the basalt microspheres have a large contact angle for the used aqueous solution. Using time resolved X-ray tomography we furthermore explore the liquid equilibration process as function of wettability of the granulate. The found liquid redistribution and the emerging liquid structures are compared to the mechanical properties of the respective granulate with identical liquid content.

CPP 35.9 Wed 17:00 P2

**Wetting of grooved elastic substrates** — ●CARSTEN HERRMANN<sup>1</sup>, DOMINIK MICHLER<sup>2</sup>, MARTIN BRINKMANN<sup>2</sup>, and RALF SEEMANN<sup>1,2</sup> — <sup>1</sup>Saarland University, Saarbrücken, Germany — <sup>2</sup>MPI DS, Göttingen, Germany

The wetting morphologies on grooved elastic substrates are considered experimentally and theoretically. The substrates are fabricated from Polydimethylsiloxane (PDMS) rubber and consist of straight parallel grooves having a rectangular shaped cross section. When liquid is deposited from the vapor phase into the grooves, the geometry of the grooves might be changed by the virtue of the capillary forces of the emerging liquid wetting morphologies. Depending on geometry and wettability of the substrate, either an attractive or repulsive force between the confining ridges of a groove results. This force leads to locally different groove geometries which are more or less attractive for the adsorbing liquid and thus a lateral ordering of the wetting morphologies occurs. We explore the lateral order and its development with time as well as the shape of the emerging liquid morphologies as function of wettability and groove geometry, i.e. the aspect ratio of both the grooves and the ridges. These experimental results are compared to results from analytical and numerical calculations minimizing the interface free energy and the bending energy of the ridges.

CPP 35.10 Wed 17:00 P2

**Static Wetting Morphologies in Topographically Structured Substrates** — ●STEFAN BOMMER<sup>1</sup>, DOMINIK MICHLER<sup>2</sup>, MARTIN BRINKMANN<sup>2</sup>, and RALF SEEMANN<sup>1,2</sup> — <sup>1</sup>Saarland University, Saarbrücken, Germany — <sup>2</sup>MPI DS, Göttingen, Germany

The different wetting morphologies of liquid confined to micron sized trapezoidal grooves are studied experimentally and theoretically. We explore the emerging equilibrium morphologies as function of groove wettability and groove aspect ratio, i.e. the ratio of groove depth to groove width. The grooves are fabricated in silicon by wet etching,

whereas the slope of the side walls is given by the crystal lattice of the silicon. The wettability of the substrate is controlled by various self-assembly monolayers and fine tuned with a subsequent oxygen plasma treatment. The wetting morphologies consist of polystyrene deposited from the gas phase and imaged by scanning force microscopy in an intermitted mode. Morphology diagrams are derived analytically by minimizing the surface free energies and compared to the experimental results.

CPP 35.11 Wed 17:00 P2

**Wetting behavior of Si surfaces decorated with well-defined nanopillars** — ●STEFAN WIEDEMANN, ALFRED PLETTL, PAUL ZIE-MANN, and KAY EGLOFF — Institute of Solid State Physics, Ulm University

To influence the wetting behavior of Si surfaces, hexagonally ordered arrays of nanoparticles were prepared in a first step by micellar or colloidal techniques combined with photoseeding. These particles are used as etching masks during a subsequent reactive ion etching step resulting in correspondingly ordered arrays of nanopillars. This approach allows a systematic variation of the height (<180 nm), density and diameter (10 to 150 nm) of the pillars. After removing the residual etching mask, hydrophobicity of the samples was additionally modified by coating with OTMS (Octadecyltrimethoxysilane) or a plasma-deposited fluorocarbon film. Such surfaces were characterized by SEM and AFM and their wetting behavior was studied by measuring advancing, static and receding contact angles of water droplets. Additionally, dewing was investigated on these nanostructures.

CPP 35.12 Wed 17:00 P2

**Microparticle Separation in Droplet Based Microfluidics** — ●MICHAEL HEIN, JEAN-BAPTISTE FLEURY, and RALF SEEMANN — Experimental Physics, Saarland University, Saarbrücken, Germany

To compartment extremely small liquid volumes into droplets and manipulate them in droplet based microfluidic systems offers the benefit of inhibiting dispersion and cross contamination of analytes. For many applications like cytometry, hematology or immunoassays molecules are attached to microbeads and subsequently dispersed in various liquids to achieve and probe certain reactions. To include those type of reactions into microfluidics devices we explore particle separation in droplets flowing in straight microfluidic channels.

Particle separation might occur inside a droplet and leads to a concentration of dispersed particles at either the front or the rear end of a droplet after a short travel distance. We explore the particle separation for several parameters like density difference of the particles and the dispersed phase, particle size, viscosities of the liquids, droplet size, channel geometry, and flow velocity. After concentrating the particles, the droplet can be split into fractions containing excess dispersed phase and a large concentration of particles, which then can be used for further microfluidic processing or analysis.

CPP 35.13 Wed 17:00 P2

**Droplet-based microfluidic techniques for the investigation of nucleation processes** — ●BIRTE RIECHERS, FRANK WITTBACHT, ALEXANDER WEDDEMANN, THOMAS KOOP, and ANDREAS HÜTTEN — Universität Bielefeld, Bielefeld, Deutschland

Nucleation is encountered in many different areas of research such as atmospheric cloud formation or phase transitions in production processes of materials. For many processes, however, the detailed mechanisms of nucleation and growth are not well understood. Thus it is of fundamental importance to develop experimental methods to study these mechanisms in more detail. One possibility is the utilization of microfluidic devices, because they allow the production of monodisperse droplets with varying diameters in the 50-500 micrometer size range.

The aim of this work is to establish a microfluidic device for the control of droplet size, shape and solute concentrations. The aqueous droplets produced in this manner can then be studied under external influences like temperature gradients in order to determine their nucleation rates as a function of temperature and droplet size. Hence, studying nucleation kinetics with the use of microfluidic devices may improve our understanding of the principles of nucleation processes.

CPP 35.14 Wed 17:00 P2

**Experimentierkiste 'Den Geheimnissen der Flüssigkeiten auf der Spur'** — ●K. JACOBS, B. JOCHUM, F. MÜLLER, A. KASABOVA, M. LIÉNARD, S. GRANDTHYLL, C. ZEITZ und C. SPENGLER — Universität des Saarlandes, Experimentalphysik, D-66041 Saarbrücken

Selbständiges Experimentieren ist ein attraktiver Weg, Schülerinnen und Schüler für Naturwissenschaften zu begeistern. Im Schulalltag fallen Einheiten zum selbständigen Experimentieren jedoch aus Gründen der Zeitknappheit oft weg. Die Experimentierkiste stellt zum Themenfeld der Physik der Flüssigkeiten einfache und robuste Versuchsaufbauten zur Verfügung. Bis zu 30 Schülerinnen und Schüler ab Klasse 8 können ohne weitere fachliche Betreuung Phänomene wie Scherverdickung, Oberflächenspannung, Viskosität erfahren, begreifen und charakterisieren. Alle Versuche sind so angelegt, dass besonders 'subjektive' Erfahrungen möglich sind, man z.B. Viskosität nicht nur als Zahl mit Einheit wahrnimmt, sondern buchstäblich begreift, wie sich eine hochviskose Flüssigkeit anfühlt. Diese Art der Experimentführung spricht auch Mädchen stark an und sorgt bei beiden Geschlechtern für eine nachhaltige Forschungserfahrung, die zu einer Wahl von naturwissenschaftlichen Neigungsgruppen animiert. Diese Experimentierkiste und eine weitere zum Thema 'Physik des Lichts' kann deutschlandweit an Schulen, Universitäten etc. versandt werden, siehe [www.experimentierkiste.de](http://www.experimentierkiste.de). Finanzielle Unterstützung erfolgt im Rahmen des DFG-Schwerpunktprogramms SPP 1164 'Nano- und Mikrofluidik', Ja905/4.

CPP 35.15 Wed 17:00 P2

**Microfluidic sorting of chiral particles** — ●MARIA ZVYAGOLSKAYA and CLEMENS BECHINGER — Universität Stuttgart, 2. Physikalisches Institut, Pfaffenwaldring 57, 70569 Stuttgart

Molecules of opposite chirality, so-called enantiomers, show different binding affinity to other molecules which may lead to unwanted chemical reactions. Therefore, sorting of molecules with different chiralities is an important task in molecular biology or pharmaceutical industry. Here, we experimentally study a separation method based on hydrodynamic forces acting on chiral particles in microfluidic vortices [1]. Three-dimensional chiral particles on a length scale of micrometers are created by a photolithographic process and labelled with fluorescent dyes according to their chirality. We study the motion of such particles in microfluidic channels with different types of rotational flows and investigate how spatial distribution of particles in a vortex corresponds to its chirality.

[1] M. Kostur, M. Schindler, P. Talkner, and P. Hänggi, *Phys. Rev. Lett.* 96, 014502 (2006).

CPP 35.16 Wed 17:00 P2

**Continuous chiral separation in a post array** — ●LUKAS BOGUNOVIC<sup>1</sup>, MARC FLIEDNER<sup>2</sup>, SONJA WEGENER<sup>1</sup>, PETER REIMANN<sup>2</sup>, DARIO ANSELMETTI<sup>1</sup>, and JAN REGTMEIER<sup>1</sup> — <sup>1</sup>Experimental Biophysics & Applied Nanoscience, Faculty of Physics, Bielefeld University, Germany — <sup>2</sup>Condensed Matter Theory, Faculty of Physics, Bielefeld University, Germany

About one half of the drugs on the market are chiral and only 25 % of all drugs are administered as pure enantiomers [1]. Because the human metabolism (as for all living organisms) functions in a highly chiral manner, it interacts differently with the two enantiomers. Consequently, the two forms have mostly different pharmacological activities underlining the need for preparational and analytical techniques. Traditionally, chiral selectors are used that specifically bind only one form. This approach, however, requires to identify a new selector for every new drug.

Here, we present the first enantioselective selector-free separation in a microfluidic post array using micrometer sized model particles. The post array is tilted with respect to the main channel axis breaking the symmetry. The sample is continuously introduced and the two enantiomers are deflected into different directions so that they could be collected in distinct reservoirs.

For future application, we would like to extend our device from quasi-2D to 3D and further miniaturize it to address drugs.

[1] G Gübtz and MG Schmid *Biopharmaceutics & Drug Disposition* 22 (2001) 291-336

CPP 35.17 Wed 17:00 P2

**Single cell protein analysis via two-color UV/VIS laser induced fluorescence detection in microfluidic devices** — ●LUKAS GALLA, DOMINIK GREIF, DARIO ANSELMETTI, and JAN REGTMEIER — Experimental Biophysics & Applied Nanoscience, Bielefeld University, Germany

In order to investigate and quantify the individual and heterogeneous cellular response, single cell analysis promises individual expression studies, which are not limited by ensemble averaging effects [1].

Upon extending our previous work on UV-LIF studies of single

cells and protein separation at ultra-low analyte concentrations [2], we present a novel detection setup that allows the simultaneous recording of UV and VIS fluorescence signals at a ms timescale in microfluidic devices.

As first results we demonstrate protein fingerprints of *Spodoptera frugiperda* insect cells (Sf9) and chinese hamster ovary cells (CHO) in UV and VIS spectral range, demonstrating the feasibility of the parallel detection. [1] J. El-Ali et al., *Nature* 442, 403, (2006), [2] D. Greif et al., *J. of Chromatography A* 1206 (1), 83, (2008).

CPP 35.18 Wed 17:00 P2

**On-chip realization of mixing and demixing nanoparticles using dielectrophoresis** — ●MARTINA EVERWAND, DARIO ANSELMETTI, and JAN REGTMEIER — Experimental Biophysics and Applied Nanoscience, Faculty of Physics, Bielefeld University, Germany

On-chip applications using microchannels are a very fast growing field of research. Point of care diagnostics or miniaturization of separation techniques are only two examples.

One distinct feature of microchannels is the laminar flow so that mixing of liquids and analytes is only driven by diffusion. Whereas a number of applications rely on that characteristic, procedures with different reaction partners are prohibitively slow. In order to investigate controlled reactions in a microfluidic device active mixing procedures are of key importance. In contrast to batch injection and detection strategies, which is a sequential process, and therefore very time consuming we explored continuous flow separations as one possibility to realize high throughput analysis, which allow further integration of functionalities up- or downstream of the separation.

Here, we present a continuous-flow application using electrodeless dielectrophoresis for efficient mixing and separation of 20 nm and 100 nm beads. A nano-microfluidic device was used with a constriction that reduces the channel height. The benefit of this device is that the parameters according to which the separation or mixing is performed can be adopted in real time while the device is running by tuning applied AC and DC voltages. This label-free technique is very promising for manipulation of polarizable biomolecules in continuous flow mode.

CPP 35.19 Wed 17:00 P2

**Microfluidic gate using self-assembling superstructures of superparamagnetic beads** — ●BERNHARD EICKENBERG, FRANK WITTBRAUCH, ALEXANDER WEDDEMANN, and ANDREAS HÜTTEN — Universität Bielefeld, Bielefeld, NRW, Deutschland

The use of magnetic beads for microfluidic applications has been thoroughly studied during the last decades. The permanent magnetic moment allows for the controlled manipulation by external (inhomogeneous) magnetic fields and the detection by magnetoresistive sensors. Depending on the ligands that are used for the functionalization of the bead surface, they can furthermore be bound to various biomolecules.

Recently, the formation of reconfigurable, self-assembling structures from superparamagnetic beads has attracted a lot of interest. While in the absence of a magnetic field the inter-particle coupling is eliminated by thermal excitation, the presence of a homogeneous magnetic field leads to alignment of the magnetic moments of the particles, causing attractive forces between the particles and the assembling of one-dimensional, chain-like superstructures. When the magnetic field is rotated in-plane, the chains follow the movement of the field direction and start to rotate.

Based on this method of external manipulation of bead superstructures by rotating homogeneous magnetic fields, a microfluidic gate was developed that allows to actively sort the flowing particles into one of two diverging channels. At flow velocities below 90 m/s, an efficiency of 95% was achieved. Thus, the system allows for a highly effective flow control without the need for complex microstructuring.

CPP 35.20 Wed 17:00 P2

**A model for swimming active droplets** — ●MAXIMILIAN SCHMITT<sup>1</sup>, SHASHI THUTUPALLI<sup>2</sup>, HOLGER STARK<sup>1</sup>, and STEPHAN HERMINGHAUS<sup>2</sup> — <sup>1</sup>Institut für Theoretische Physik, TU Berlin — <sup>2</sup>Max-Planck-Institut für Dynamik und Selbstorganisation, Göttingen

In a recent attempt to build an active microswimmer, a micron-sized droplet of bromine water was placed into a surfactant laden oil medium such that the surfactant molecules spontaneously assemble at the droplet interface. Experiments revealed that due to a bromination reaction, the chemical potential of the surfactant (mono-olein) increases causing the surface tension to increase locally. At the same time these surfactants with a higher surface tension are readily replaced by surfactants from the surrounding oil phase. As a result, a steady gradient

of surface tension on the droplet is created. Since an interface with higher surface tension pulls more strongly on a surrounding liquid than one with a lower surface tension, the surface tension gradient on the droplet generates the so-called Marangoni flow. Measurements of the flow around a swimming droplet revealed a flow field similar to that of a squirmer, which is a model for a spherical micro-swimmer with prescribed flow velocity on the surface.

In this contribution we construct a first simple model of the swimming mechanism of the active droplets. We establish a reaction-diffusion system on a sphere which comprises the bromination of the surfactants and the flux of new surfactants from the oil phase to the droplet. In a second step we want to simulate the flow field created by the surface-tension gradient and compare it to the measured flow field.

CPP 35.21 Wed 17:00 P2

**Gold Capped Microparticles as Self-Propelled Switchable Swimmers** — ●ANDREAS BREGULLA<sup>1</sup>, MARKUS SELMKE<sup>1</sup>, RALF SEIDEL<sup>2</sup>, MICHAEL MERTIG<sup>3</sup>, KLAUS KROY<sup>4</sup>, and FRANK CICHOS<sup>1</sup> — <sup>1</sup>Molecular Nanophotonics Group, University Leipzig, Linnéstraße 5, 04103 Leipzig — <sup>2</sup>DNA Motors Group, BioTeC, University of Technology Dresden, Tatzberg 47-51, 01307 Dresden — <sup>3</sup>Physikalische Chemie, Mess- und Sensortechnik, Technische Universität Dresden, Eisenstückstr. 5 01069 Dresden — <sup>4</sup>Soft Condensed Matter Theory Group, University Leipzig, Vor dem Hospitaltore 1, 04103 Leipzig

Nanotechnology requires the independent transport of materials by nanoscale machinery in solution. Following this idea a number of concepts on self-propelled swimmers were realized during recent years. Most of them are based on catalytic reactions requiring fuel in the solution. Due to this such self-propelled swimmers are non-switchable, they run until they are out of fuel. Further they cannot be controlled on an individual basis, thus either all swimmers run or none. Here we present a new concept based on self-thermophoretic action. A particle which is capped by a thin metal layer is heated by a laser beam causing a temperature gradient along the particle surface. This temperature gradient leads to a thermophoretic propulsion of the particle. The speed as well as the directed motion itself can be controlled on an individual particle basis and thus allows a whole set of new types of artificial micro- and nanoscale motors.

CPP 35.22 Wed 17:00 P2

**Gold Nanoparticle Deposition onto a Microstructured Polymer-coated Substrate Using a Flow-Stream Technique** — ●GERD HERZOG<sup>1,2</sup>, ADELIN BUFFET<sup>1</sup>, JAN PERLICH<sup>1</sup>, MOTTAKIN M. ABUL KASHEM<sup>1</sup>, MATTHIAS SCHWARTZKOPF<sup>1</sup>, GUNTARD BENECKE<sup>1</sup>, VOLKER KÖRSTGENS<sup>3</sup>, PETER MÜLLER-BUSCHBAUM<sup>3</sup>, RAINER GEHRKE<sup>1</sup>, WILFRIED WURTH<sup>2</sup>, and STEPHAN V. ROTH<sup>1</sup> — <sup>1</sup>HASYLAB at DESY, Notkestr. 85, D-22607 Hamburg, Germany — <sup>2</sup>Universität Hamburg, Institut für Experimentalphysik, Luruper Chaussee 149, D-22761 Hamburg, Germany — <sup>3</sup>TU München, Physik Department, LS Funkt. Mat., James-Franck-Str. 1, 85748 Garching, Germany

Metal nanostructures are widely used in electronic components. Production of nanowires by deposition of gold nanoparticles out of a suspension via flow-stream technique onto a nanostructured polymer-coated substrate might offer an easy, cheap and fast solution for industrial application [1].

Here, we present an experiment in which a colloidal suspension of polystyrene nanoparticles in water is spin-coated onto a glass substrate

which is subsequently rubbed with velvet to create micrometer-sized channels. A microfluidic device is used to let an aqueous suspension of gold nanoparticles flow across the coated substrate [2]. In situ GISAXS shows the progressive deposition of gold nanoparticles onto the substrate.

[1] E. Metwalli et al., *Langmuir* 2009, 25(19), 11815

[2] J.-F. Moulin et al., *Rev. Sci. Instrum.* 79, 015109 (2008)

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**Influence of an electric field on the two phase flows in porous media** — ●BENOÎT SEMIN, MATTHIAS SCHRÖTER, and JEAN-CHRISTOPHE BARET — Max-Planck Institut für Dynamik und Selbstorganisation, 37073 Göttingen, Germany

The use of an electric field to enhance oil recovery from porous media has been reported at both the sample and the field scales [1]. Here, we present an experimental study of this effect at the pore scale. To control and visualize the flow, we use microfluidic devices in which a model porous media is embedded. The latter is either an irregular array of pillars (2D) or a chamber filled with glass beads (3D). This model porous media is first filled with the wetting fluid (fluorinated oil) and then the non-wetting fluid (aqueous solution) is injected. The aqueous solution is dyed to allow for the measurement of the aqueous solution and oil saturations. An electric field is applied using electrodes patterned on the microfluidic device and the influence of the external electric field on the residual oil saturation is investigated. The coupling between the flow and the electric field can involve several physical mechanisms such as electro-osmosis, electrowetting and dielectrophoresis [2]. The variation of the fluid properties (salt concentration, permittivity) and of the electric field (magnitude and frequency) can be used to determine the dominant mechanism on the oil retention. [1] Wittle and Bell, US Patent 7325604 (2008) [2] Tabeling, *Introduction to Microfluidics* (2006)

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**Droplet-based microfluidic systems for dynamic surface tension measurements** — ●QUENTIN BROSEAU and JEAN-CHRISTOPHE BARET — Max Planck Institute for Dynamics and Self-organization

The accurate characterization and the control of interfaces is of primary importance for various fields of research, from material sciences to cell biophysics. Although surface tension – one key parameter to describe interfaces – is a concept well defined for interfaces between pure liquids or in static conditions, many questions arise with the dynamics of adsorption of surfactant molecules at the interfaces [1,2] and we are facing a lack of tools to study these dynamic processes. Our aim is to develop new tools for measurement of dynamic surface tensions [2]. The idea is to produce and flow droplets in surfactant solutions through microchannel designed to induce deformations of the droplet. These deformations are controlled by the balance of viscous stress and the surface tension [3] and will allow dynamic measurement, down to millisecond time-scale. The measurements of the increase of droplet deformation with time, shows that the surface tension is decreasing along the microchannel. After a transient phase, a steady-state is reached in which surfactant is in dynamic equilibrium with the continuous phase. The characteristic time for this process is of the order of a few millisecond. By varying both the nature of surfactant and its concentration, we will look for universal behavior governing the build up of interfaces.

[1] J. Bibette, *Emulsions: basic principles* Rep. Prog. Phys., 62, 969 (1999); [2] J.-C Baret & al., *Langmuir*, 25(11), 6088 (2009); [3] J. Cabral & al., *Lab Chip*, 6, 427 (2006)