

BP 11: Micro- and Nanofluidics

Time: Tuesday 16:00–17:15

Location: H43

BP 11.1 Tue 16:00 H43

DNA Dielectrophoresis in Microfluidic Systems: Separation and Polarizability — •HENNING HÖFEMANN¹, JAN REGTMEIER¹, RALF EICHHORN², DARIO ANSELMETTI¹, and ALEXANDRA ROS¹ —

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Electrophoresis (EP) and dielectrophoresis (DEP) represent an important tool for the manipulation of DNA in microfluidic systems. Recently, we have demonstrated that the DEP and EP forces can be exploited in tailored microfluidic systems to separate long DNA strands and to quantitatively access their polarizabilities [1]. The microfluidic device includes periodically arranged rows of posts generating DEP traps for DNA upon application of an AC voltage. Further an additional DC voltage invokes migration of DNA through the microchannel. The subtle interaction of the DNA with the created energy landscape, tuned by the parameters of the DC offset and AC conditions (amplitude and frequency) allows a precise control of the length dependent migration and trapping of DNA. Here, we extend our studies and demonstrate the length dependent migration of covalently closed circle DNA in a size range between 7 and 23 kpb including the quantitative deduction of DNA polarizabilities. Our future work is dedicated to the exploitation of this novel migration mechanism to the separation of DNA varying in length and conformation. [1] J. Regtmeier, T. T. Duong, R. Eichhorn, D. Anselmetti, A. Ros; Dielectrophoretic Manipulation of DNA: Separation and Polarizability, 2006, submitted

BP 11.2 Tue 16:15 H43

Self-propulsive motions of elastic filaments — •HIROFUMI WADA and ROLAND NETZ —

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Microbiology provides rich examples of self-propulsive motions in a viscous fluid, where inertia plays no role and the concept of momentum conservation does not work. In such a inertia-less limit, the Navier-Stokes equation is linearized, leading to the conclusion that geometrically reversible motion does not render any net thrust. Using hydrodynamic simulations, we study propulsive behavior of a few types of model-Stokesian swimmers with slender filaments, such as a rotating elastic rod and bistable helices. The generation of a shape change through an elastic instability or an active excitation results in a substantial forward thrust. The hydrodynamic efficiency, as well as its optimum condition, is examined in presence of thermal fluctuations. Its biological connection is also discussed.

BP 11.3 Tue 16:30 H43

Light Driven Microfluidics — •FRANZ WEINERT and DIETER BRAUN —

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Microfluidics will play a major role for complex liquid manipulation in a wide variety of biological and chemical applications of the life sciences. In conventional microfluidics, liquid is pumped and switched through lithographically defined channels. Such microfluidic chips have to connect to a considerable complex interface for pumping, switching and providing the liquids.

We present an all-optical fluid flow control, which allows highly flexible and dynamic liquid handling, both in microfluidic channels and twodimensional gels. The fluid follows the arbitrary shaped path of an infrared laser scanning microscope without the need for microfluidic

tubings and valves.

The physics behind is thermal expansion in a viscosity gradient, an effect previously not considered. We derive an analytical solution for the pump speed directly from the Navier-Stokes equations. Thermal relaxation is on the millisecond time scale and allows fast repetition of the laser spot movement. Pump speed rises quadratically for decreasing thickness, making the mechanism perfectly suitable for Nanofluidics. Under moderate conditions, pump speeds are 20 $\mu\text{m/s}$ in a 2.5 μm thin water film. Notably, highly viscous liquids can be equally pumped. The novel mechanism allows highly miniaturized microfluidics under dynamic control without predefined channels.

BP 11.4 Tue 16:45 H43

Ionic currents in nanochannels and carbon nanotubes —

•CHRISTINE MEYER, JERON DE GREBBER, VISHAL MERANI, DEREK STEIN, FRANK VAN DER HEYDEN, MARC ZUDDAM, EMILE VAN DER DRIFT, and CEES DEKKER — Kavli Institute of Nanoscience, TU Delft, The Netherlands

The behaviour of electrolyte solutions in small confinements can differ a lot from bulk behaviour. This makes salt solutions in artificial nanofluidic channels an interesting subject for investigation.

Nanofluidic channels were fabricated using a sacrificial etch process. A sacrificial silicon layer that mimics the channel is covered with silicon oxide. Once the sacrificial layer is etched away selectively, a channel is created that we fill with an electrolyte solution. Using the same fabrication scheme, we plan to integrate a single-wall carbon nanotube as an ultimately small fluidic channel.

We investigated the ionic conductance of nanochannels as a function of salt concentration and found a saturation in the low-salt regime. With respect to the expected bulk conductance, the current in the saturation regime is enhanced. We can explain this by assuming that ions in the Debye layer, i.e. ions that screen surface charges, become the dominant charge carriers in this regime. If we can change the surface charge e.g. electrically, the conductance of the channel should change accordingly, which would lead to an "ionic transistor".

BP 11.5 Tue 17:00 H43

Thermophoretic Biomolecule Analytics — •STEFAN DUHR and DIETER BRAUN —

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Molecules drift along temperature gradients, an effect called thermophoresis, Soret-effect or thermodiffusion. We present a recently developed microscopic theory [1] based on solvation entropy. Stated in simple terms, the Soret coefficient is given by the negative solvation entropy, divided by kT . The theory predicts the thermodiffusion of polystyrene beads and DNA without any free parameters. This description holds as long as particles are in local thermodynamic equilibrium, which is valid for small molecules at moderate temperature gradients. Based on this theory, slight changes of surface properties on the molecular level lead to profound changes in thermophoretic behavior. We show experimental results for fast molecule characterization by thermophoresis. Thermal gradients provide a good tool to differentiate between DNA of different length within a few seconds, but they also allow for detection of biomolecule interactions. Thermophoresis may prove a very effective technique for biotechnological applications.

Reference: [1] S.Duhr and D.Braun, Why molecules move along a temperature gradient, PNAS, in press