BP 27: Biotechnology and Bioengineering

Time: Thursday 9:30–12:00 Location: H43

Topical Talk BP 27.1 Thu 9:30 H43

DNA Origami: Applications in Physics and Biotechnology — •Tim Liedl — Center for Nanoscience, LMU, Munich, Germany

DNA Nanotechnology makes use of programmable DNA strands for the construction of self-assembling two- and three-dimensional objects of nano-engineered shapes [1]. Through the introduction of the extremely robust DNA origami technique [2] the field experienced exciting developments during the last years. I will present recent applications of DNA origami in physics and biotechnology and will show, e.g., how the method can be employed for the fabrication of self-assembled plasmonic materials [3, 4]. Through literally nanometer-precise control over the arrangement of nanoparticles, we were able to create chiral plasmonic structures that exhibit pronounced circular dichroism and optical rotatory dispersion. In recent experiments we were able to orient the nanoparticle helices and observe increased optical activity. These results demonstrate the potential of DNA origami for the assembly of plasmonic metafluids with tailored optical properties.

1. N. C. Seeman, "Nanomaterials based on DNA", Annu. Rev. Biochem. 79, 12.1-12.23 (2010). 2. P. W. K. Rothemund, "Folding DNA to create nanoscale shapes and patterns", Nature 440, 297*302 (2006). 3. A. Kuzyk et al., "DNA-based Self-Assembly of Chiral Plasmonic Nanostructures with Tailored Optical Response", Nature 483, 311-314 (2012). 4. D. Smith et al., "Nucleic Acid nanostructures for nanomedicine applications", Nanomedicine 8, in press (2013)

BP 27.2 Thu 10:00 H43

Synthetic ion channels made from DNA — Martin Langecker, Vera Arnaut, Thomas G. Martin, Jonathan List, Hendrik Dietz, and •Friedrich C. Simmel — Physik Department, TU München

We created a new type of synthetic lipid bilayer membrane channel with user-defined geometric specifications that is constructed entirely from DNA. We show that these synthetic channels can be incorporated into lipid bilayer membranes and we study their electrical properties by single-channel electrophysiological measurements. We find remarkable similarities to the behavior of biological ion channels such as "gating" caused by molecular fluctuations within the channel structure. We also demonstrate one of many potential applications of the synthetic ion channels, namely as single-molecule sensing devices.

BP 27.3 Thu 10:15 H43

Diffusion and freezing transition of rod-like DNA origami on freestanding lipid membranes — •Eugene P. Petrov[1,2], Aleksander Czogalla[2], Dominik J. Kauert[3], Ralf Seidel[3], and Petra Schwille[1,2] — [1]Max Planck Institute of Biochemistry, Department of Cellular and Molecular Biophysics, 82152 Martinsried, Germany — [2]Biophysics, BIOTEC, Technische Universität Dresden, 01307 Dresden, Germany — [3]DNA Motors, BIOTEC, Technische Universität Dresden, 01307 Dresden, Germany

During the last decade, DNA origami has become a powerful tool in research at the nanoscale. The relative ease of constructing functionalized DNA origami structures of a defined shape allows for their applications in membrane biophysics. Recently, we have constructed stiff rod-like DNA origami structures consisting of six DNA helixes, which were functionalized with hydrophobic membrane-binding anchors and fluorescently labeled at defined positions [1]. Selective fluorescent labeling allowed us to determine the translational and rotational diffusion coefficients of the DNA origami rods on lipid membranes by fluorescence correlation spectroscopy, which were found to be in a good agreement with the hydrodynamics-based theory of membrane diffusion. Further, we studied the effect of the surface density of membrane-bound origami structures on their Brownian motion. Our results indicate that the 2D membrane hydrodynamics plays an important role in determining the onset of the freezing transition for membrane-bound nanorods.

[1] A. Czogalla, E. P. Petrov, D. J. Kauert, V. Uzunova, Y. Zhang, R. Seidel, and P. Schwille, *Faraday Discuss.* (2013) in press

BP 27.4 Thu 10:30 H43

Biological applications for nano-mechanical detection of molecular recognition — •Andreas Mader[1], Kathrin Gruber[1], Roberto Castelli[2], Peter Seeberger[2], Joachim Rädler[1], and Madeleine Leisner[1] — [1]LMU München, Fakultät für Physik — [2]Department of Biology, Chemistry and Pharmacy, Freie Universität Berlin

Advances in carbohydrate sequencing technologies have revealed the tremendous complexity of the glycome. Understanding the biological function of carbohydrates requires the identification and quantification of carbohydrate interactions with biomolecules. The increasing importance of carbohydrate-based sensors able to specifically detect sugar binding molecules or cells, has been shown for medical diagnostics and drug screening. Our biosensor with a self-assembled mannoside based sensing layer that specifically detects carbohydrate-protein binding interactions (mannoside - ConA), as well as real time interaction of carbohydrates with different E.coli strains in solution. Binding on the Cantilever surface causes mechanical surface stress, that is transduced into a mechanical force and cantilever bending. The degree and duration of cantilever deflection correlates with the interaction's strength. During this study we could establish that carbohydrate-based cantilever biosensing is a robust, label-free, and scalable method to analyze carbohydrate-protein and carbohydrate-bacteria interactions [1]. The cantilevers thereby exhibit specific and reproducible deflection with a high sensitivity range of over four orders of magnitude.

[1] A.Mader et al. NanoLetters, 2012, 12 (1), pp 420-423

15 min break

BP 27.5 Thu 11:00 H43

In-situ electrostatic trapping and manipulation of single nano-objects — •Ji Tae Kim[1,2] and Vahid Sandoghdar[1,2] — [1]Max Planck Institute for the Science of Light, 91058 Erlangen, Germany — [2]Friedrich-Alexander University Erlangen-Nürnberg, 91058 Erlangen, Germany

Direct observation of single molecules in their natural environment is essential for fundamental studies. Many sophisticated trapping methods have been developed to counter the randomizing effect of Brownian motion, but stable trapping of small nanoscopic objects still remains a great challenge. A recent breakthrough showed that charged nano-objects could be trapped in geometry-induced electrostatic potentials on prefabricated nanofluidic chips. Here we extend this technique to in-situ electrostatic trapping that exploits the topological modulations produced by a glass nano-capillary. This arrangement allows us to control and manipulate the nanoparticle dynamically at the nanometer scale. We present our results and discuss the prospects of our work for applications in nanobiophysics.

BP 27.6 Thu 11:15 H43

Membrane protein synthesis in giant vesicles — •Susanne Fenz[1,3], Rita Sachse[2], Stefan Kubick[2], and Thomas Schmidt[3] — [1]Biozentrum, Würzburg, Germany — [2]IBMT, Potsdam-Golm, Germany — [3]Leiden University, Leiden, Netherlands

Interest in the development of biomimetic cell models is driven by its potential to go beyond a purely descriptive picture of cellular processes towards a quantitative understanding and rigorous validation of theoretical modeling.

Recently we introduced a protocol to prepare advanced cell models from giant unilamellar vesicles for studies of membrane processes that involve transmembrane proteins. We further showed that specific functionalization permits to use those biomimetic systems in a lab-on-a-chip scenario. Building on this development, we present here a novel approach that allows us to realize a mimetic cell model that includes in situ protein synthesis and active membrane translocation. Giant unilamellar vesicles were prepared starting from eukaryotic cell lysates containing both the eukaryotic protein synthesis machinery as well as the translocon that is required to integrate proteins into membranes. Our soft methodology for vesicle preparation on agarose-coated surfaces allowed us to keep the translocon fully functional. The advantage of in situ expression and translocation as described here to earlier attempts to produce giant proteo-liposomes is that all proteins are built into the vesicle membrane in the correct orientation. Our novel cell model opens up the possibility to study e.g. protein synthesis in vitro with single-molecule microscopy.

BP 27.7 Thu 11:30 H43

Tailoring substrates for long-term organotypic culture of adult neuronal tissue — •Mareike Zink[1], Valentina

Dallacasagrande[1,2], Alexander Jakob[3,4], Marcus Müller[3], Andreas Reichenbach[2], Josef Käs[1], and Stefan G. Mayr[3,4] — [1]Institut für Experimentelle Physik 1, Universität Leipzig — [2]Paul-Flechsig-Institut, Universität Leipzig — [3]Leibniz Institut für Oberflächenmodifizierung e.V., Leipzig — [4]Translationszentrum für Regenerative Medizin, Fakultät für Physik und Geowissenschaften, Universität Leipzig, Leipzig, Germany

Organotypic tissue cultures establish a highly promising approach for performing in vivo type of studies in vitro. However, very limited survival times of only a few days for adult tissue often limit their application. We propose a novel biotechnological concept, which allows for unprecedented long culture times even in absence of biochemical growth factors. Employing TiO2 nanotube array substrates, whose interaction properties with individual cells and the overall tissue can be tuned by the tube parameters, we verify this concept for different adult neuronal explants, which are successfully cultured for the first time longer than 14 days with no indications of degeneration. It turned out that adequate nanotube diameter, wall thickness and surface roughness vary for successful long-term culture of adult mammalian retinae and brain slices. Additionally, we found that the intrinsic super-hydrophilicity of the substrates allows for a continuous supply of fresh medium without perfusion systems. Our findings pave the way for in vitro drug testing, as well as neuronal tissue regeneration.

BP 27.8 Thu 11:45 H43

Advanced high-throughput SEIRA methodology for multiplexed bioassay assessment — •Andrea Hornemann[1], Sabine Flemig[2], Gerhard Ulm[1], and Burkhard Beckhoff[1] — [1]Physikalisch-Technische Bundesanstalt (PTB), Abbestr. 2-12, 10587 Berlin, Germany — [2]BAM Bundesanstalt für Materialforschung und -prüfung, Richard-Willstätter-Str.10, 12489 Berlin, Germany

Nanotechnology has an increasing impact in both the design and functionality of biomedical and biodiagnostic devices for a reliable high-performance analysis. High-throughput technological advances in diagnostic assays of high complexity induce requirements on selectivity, sensitivity, and multiplexing capability that will be the main challenges for the prospective assay design. We discuss the capability of surface-enhanced infrared absorption (SEIRA) spectroscopy as versatile diagnostic readout tool for both its potential widespread point-of-care use and application for the multiplexed bioassay assessment. We performed a qualification study on NP-enhanced SEIRA, enabling the readout of tunable assays. We utilized synchrotron radiation as its high brilliance provides an improved quality of spectral datasets and low data acquisition times. Our analysis included a profound study on nanoscaled biolabels that exhibit distinct narrow emission profiles of the incorporated antibody-fluorophore complexes. The molecular fingerprints have been successfully analyzed by multivariate methods with respect to their multiplexing capabilities. This robust spectral encoding by SEIRA signatures is expected to open new opportunities for a fast, reliable and multiplexed high-end screening in biodiagnostics.