CPP 4: Bioinspired Functional Materials I

Time: Monday 10:15–13:00 Location: ZEU 114

Invited Talk CPP 4.1 Mon 10:15 ZEU 114

Membrane nanotube formation in giant vesicles — •Rumiana Dimova — Max Planck Institute of Colloids and Interfaces, Science Park Golm, 14424 Potsdam, Germany

Nanotubes are ubiquitous in cells. Examples for tubular structures are provided not only by organelles such as the Golgi body and the endoplasmic reticulum but also by intercellular connections between different cells. Their geometry and large area-to-volume ratio make them an excellent natural tool for membrane storage, sorting and transport. Such nanotubes can also be formed from synthetic lipid bilayers. Here, we discuss two systems based on giant vesicles, within which lipid nanotubes are generated and stabilized by spontaneous curvature. In the first case, we employ membranes doped with the ganglioside GM1 (Biophys. J. 111:1935, 2016). Upon dilution, the vesicle membrane exhibits asymmetric composition set by the different surface GM1 coverage on the two membrane leaflets. Employing vesicle micromanipulation and electroporation, we could assess the GM1 asymmetry and the associated spontaneous curvature. In the second system, the two leaflets of the bilayer have the same composition, but the solutions in contact with the inner and outer leaflet differ in the concentration of polyethylene glycol (PEG). We show that the spontaneous curvature is now generated by weak adsorption of PEG onto the membranes (ACS Nano 10:463, 2016). The tube shapes, cylindrical or necklace-like, and their diameters can be varied by the membrane composition and bending rigidity. We demonstrate this variation by employing membranes in the liquid-ordered and liquid-disordered phase state.

CPP 4.2 Mon 10:45 ZEU 114

Traction forces of water droplets on superhydrophobic pillar structures — •Schellenberger Frank, Saal Alexander, and Tress Martin — Max Planck Institute for Polymer Research, Mainz, Germany

Surfaces with super-hydrophobic properties play an important role in both nature and science. Thereby, the artificial surfaces typically try to copy the characteristic features of their natural pendants. That is in general, a hydrophobic surface chemistry combined with a structured topography. To investigate the particular impact of these characteristics model surfaces with pillars of varying size, arrangement and surface coating have been employed [1]. While many studies used rigid pillars to maintain a well-defined topography, in the present work flexible pillars are focused. When imaged with a Laser Scanning Confocal Microscope, these flexible pillars act as cantilevers to detect traction forces of a drop resting on their top. By that, the distribution of the forces in parallel to the surface along the contact line is recorded. Especially the traction forces of the receding contact line of an evaporating or advancing drop will be illuminated.

[1] P. Papadopoulos et al. PNAS 9 (2013) 3254

CPP 4.3 Mon 11:00 ZEU 114

Functional biohybrid materials: Centric diatoms with incorporated donor-acceptor laser dye couples — Lukas Selzer, Michael Grimann, and •Thomas Fuhrmann-Lieker — University of Kassel, Institute of Chemistry and Center for Interdisciplinary Nanostructure Science and Technology, 34109 Kassel, Germany

Centric diatoms are unicellular algae with an intricate cell wall of silica that can be described as a photonic crystal slab waveguide. The photonic function can be enhanced by the incorporation of laser dyes, turning the living algae into active fluorescent light-emitters. In order to increase the photoluminescence efficiency, we achieved dual in-vivo-staining with a dye pair for fluorescence resonant energy transfer (FRET). In addition to applications in photonics, this method allows the determination of the acceptor dye concentration in the hybrid material.

CPP 4.4 Mon 11:15 ZEU 114

DNA based assembly of plasmonic nanoantennas — •Mathias Lakatos[1], Hanna Brunner[1], Darius Pohl[2], Andreas Heerwig[1], Bernd Rellinghaus[2] und Michael Mertig[1] — [1]TU Dresden, Physikalische Chemie, Mess- und Sensortechnik, 01062, Dresden — [2]IFW, Institut für Metallische Materialien, 01171 Dresden

Based on the ability of DNA to self-assemble into complex 2D and 3D structures with defined dimensions and structure specification at the nanometer scale, optical active nanostructures were synthesized and characterized. The preparation of the DNA template structures was done according to the so-called DNA origami method, where a long single-stranded DNA, the scaffold strand, is folded into a previously designed form by short single-stranded oligonucleotides. The incorporation of specific binding sites enables the local positioning of functional elements. For the construction of plasmonic active nanoantennas, complementary functionalized AuNR were used. Depending on the DNA template structures and the gold nanoparticles, nanoantennas of about 100 nm up to 300 nm size have been realized. Low-loss electron energy loss spectroscopy measurements were carried out using monochromated scanning transmission electron microscopy (STEM) on individual structural elements to gain insight into the localization of different plasmonic modes.

15 min break

CPP 4.5 Mon 11:45 ZEU 114

Vesicles-on-a-chip : A universal microfluidic platform for the assembly of liposomes and polymersomes — •Julien Petit[1], Ingmar Polenz[1], Laura Thomi[2], Frederik Wurm[2], Jean-Christophe Baret[3], Katharina Landfester[2], Stephan Herminghaus[1], and Oliver Bäumchen[1] — [1]Max Planck Institute for Dynamics and Self-Organization (MPI-DS), 37077 Göttingen, Germany — [2]Max Planck Institute for Polymer Research (MPI-P), 55128 Mainz, Germany — [3]Centre de Recherche Paul Pascal (CRPP), CNRS, Université de Bordeaux, 33600 Pessac, France

One key challenge nowadays for a "bottom-up" approach in synthetic biology relies on the fabrication of compartments such as vesicles that can be viewed as model membranes. Nevertheless, the development of reliable methods for the high-throughput production of vesicles in an easy and well-controlled manner is still in progress. In this context, we propose a versatile method for producing monodisperse liposomes as well as polymersomes on the exact same PDMS-based microfluidic platform from double-emulsions [J. Petit et al., EPJE 39: 59 (2016)]. The size of the vesicles obtained with this technique can be varied over at least one order of magnitude and they are stable for more than 3 months under ambient conditions. Furthermore, we demonstrate the versatility of this microfluidic platform by producing polymersomes composed of functionalized block-copolymers. We characterize the successful functionalization by fluorescent labeling and measure the specific adhesion of polymersomes on dedicated surfaces using a micropipette force sensor technique.

CPP 4.6 Mon 12:00 ZEU 114

Passive Polymer Translocation Through Membranes: An Edwards Model Based Guideline — •Marco Werner[1,2], Jasper Bathmann[3], Vladimir Baulin[1], and Jens-Uwe Sommer[2] — [1]Universitat Rovira i Virgili, Tarragona, Spain — [2]Leibniz-Institut für Polymerforschung Dresden, Dresden, Germany — [3]Technische Universität Dresden, Dresden, Germany

We propose a theoretical framework for examining translocation of flexible polymers through amphiphilic membranes: A generic model for monomer-membrane interactions is formulated and the Edwards equation is employed for calculating the free energy landscape of a polymer in a membrane environment. By the example of homopolymers it is demonstrated that polymer adsorption and the symmetry of conformations with respect to the membrane's mid-plane trigger passive polymer translocation in a narrow window of polymer hydrophobicity. We demonstrate that globular conformations can be taken into account by means of a screening of the external potential, which leads to excellent agreement of predicted translocation times with dynamic lattice Monte Carlo (MC) simulations. The work opens a theoretical road-map on how to design translocating flexible polymers by referring to universal phenomena only: adsorption and conformational symmetry. As confirmed by MC simulations on amphiphilic polymers, promising candidates of translocating polymers in practice are short-block amphiphilic copolymers, which in the limit of small block sizes resemble homopolymers on a coarse grained level.

CPP 4.7 Mon 12:15 ZEU 114

The Bicontinuous Gyroid-Phase in Purely Entropic Self-

Assembly of Hard Pears — •Philipp Schönhöfer[1,2], Laurence Ellison[3], Matthieu Marechal[2], Douglas Cleaver[3], and Gerd Schröder-Turk[1] — [1]School of Engineering and Information Technology, Murdoch University, Murdoch, Australia — [2]Institut für Theoretische Physik I, Universität Erlangen-Nürnberg, Erlangen, Germany — [3]Materials and Engineering Research Institute, Sheffield Hallam University, Sheffield, UK

We investigate a model of tapered hard particles reminiscent of pears forming the bicontinuous Ia3d structure by entropic self assembly. Based on the observations of Barmes et al. and Ellison et al. a phase diagram for particles with an aspect ratio $k = 3$ in relation to the degree of tapering k_θ and the tapering angle $\theta = 2\arctan(\frac{1}{2k_\theta})$, respectively, around the gyroid phase is generated. Additionally, the mechanism of interdigitating sheets of pears in these systems to create surfaces with negative Gauss curvature, which is needed to form the gyroid minimal surface is investigated in detail. We show that this mechanism differs from systems, which occur in nature (lipid bilayers) and synthesized materials (di-block copolymers) and where the formation of the gyroid is energetically driven, as for single hard pears do not follow Steiner*s theorem. This behaviour is investigated by Voronoi tessellation, whereas both shape and volume of the Voronoi cells in regard to the gauss curvature of the gyroid surface is determined.

[1] F. Barmes et al., Phys. Rev. E 68, 021708 (2003)
[2] Ellison et al., Phys. Rev. Lett. 97, 237801 (2006)

CPP 4.8 Mon 12:30 ZEU 114

Probing Adhesion with Mechano-Responsive Polymers — •Jens W. Neubauer[1], Longjian Xue[2], Johann Erath[3], Dirk-M. Drotlef[4], Aránzazu del Campo[5], and Andreas Fery[1,6] — [1]Leibniz-Institut für Polymerforschung Dresden e.V., Germany — [2]Wuhan University, China — [3]University of Bayreuth, Germany — [4]Max-Planck-Institut für Polymerforschung, Mainz, Germany — [5]Leibniz-Institut für Neue Materialien, Saarbrücken, Germany — [6]Technische Universität Dresden, Germany

We use mechano-responsive polymers to elucidate adhesion. In gecko-inspired micropillar adhesives, for instance, a significant impact of the pillar contact geometry on the adhesion was found. Fundamental differences in their contact stress distributions were predicted by theory. We applied a mechano-responsive polyelectrolyte brush to determine the contact stress distributions of the micropillars. The mechano-response is based on the quenching of a labeled dye so that local tensile and compressive stresses affect the local fluorescence intensity. It was read out with high spatial resolution utilizing confocal laser scanning microscopy.

J.W. Neubauer, L. Xue, J. Erath, D.-M. Drotlef, A. del Campo, A. Fery *ACS Appl. Mater. Interfaces* **8** (2016), 17870-17877.

CPP 4.9 Mon 12:45 ZEU 114

Theoretical quantification of nano carrier loading and release rates — •Richard Schwarzl[1], Fang Du[2], Rainer Haag[2], and Roland R. Netz[1] — [1]Freie Unversität Berlin, Fachbereich Physik, Arnimallee 14, 14195 Berlin — [2]Freie Unversität Berlin, Institut für Chemie und Biochemie, Arnimallee 14, 14195 Berlin

Macromolecular nanostructures that are used as drug carriers are characterized by their loading and release kinetics. Release studies commonly employ the dialysis method, in which a cellulose membrane separates the solution of released drug from the nanocarrier solution. In order to extract the nano carrier release rate, it is necessary to take the effect of the dialysis membrane on the release kinetics into account. Using a theoretical two-step approach, consisting of the analysis of a calibration experiment of drug diffusion through the dialysis membrane in the absence of nanocarriers, and of an experiment in the presence of nanocarriers, one is able to determine all kinetic rates and in particular to disentangle kinetic dialysis membrane properties from kinetic nanocarrier properties.