BP 4: Posters Biological Physics

Time: Thursday 11:15–12:15 Location: P

BP 4.1 Thu 11:15 P

Gelation dynamics upon pressure-induced liquid-liquid phase separation in a water-lysozyme solution — Marc Moron[1], •Ahmed Al-Masoodi[2], Clementine Lovato[2], Mario Reiser[3], Lisa Randolph[2], Göran Surmeier[1], Jennifer Bolle[1], Fabian Westermeier[4], Michael Sprung[4], Metin Tolan[1], Roland Winter[5], Michael Paulus[1], and Christian Gutt[2] — [1]Fakultät Physik / DELTA, TU Dortmund, 44221 Dortmund, Germany — [2]Department Physik, Universität Siegen, 57072 Siegen, Germany — [3]Department of Physics, Stockholm University, 10691 Stockholm, Sweden — [4]Deutsches Elektronen Synchrotron DESY, 22607 Hamburg, Germany — [5]Fakultät Chemie und Chemische Biologie, Physikalische Chemie, TU Dortmund, 44221 Dortmund, Germany

Phase transitions in concentrated protein solutions have been in the focus of research for years. For example, many diseases can be attributed to protein aggregation or liquid-liquid phase separation in human cells. Lysozyme represents a well-studied model protein. We investigated the effect of hydrostatic pressure on concentrated lysozyme solutions in different environments and were able to show that besides temperature, protein concentration, cosolvents and ionic strength also the hydrostatic pressure modulates the protein-protein interaction. Up to now, only the static properties of the lysozyme solutions were characterized. In this work, we present first pressure dependent X-ray photon correlation spectroscopy (XPCS) measurements on concentrated lysozyme solutions to study the dynamics of pressure-induced liquid-liquid phase transitions.

BP 4.2 Thu 11:15 P

Nonlinear viscoelastic behavior and hysteresis in hydrated collagen fibrils — •Martin Dehnert, Paul Zech, and Robert Magerle — Fakultät für Naturwissenschaften, Technische Universität Chemnitz, Germany

We study the nanomechanical properties of hydrated collagen fibrils with AFM-based nanoindentation measurements. Force–distance (FD) data measured with tip velocities $< 1\,\mu$m/s and different indentation protocols (force relaxation, creep, and cyclic loading) display nonlinear viscoelastic and elastoplastic behavior: (a) stress relaxation with a time constant $\tau_R \sim 0.1$ s, (b) creep with a time constant $\tau_C \sim 5$ s, and (c) approximately rate-independent hysteretic behavior with return point memory at intermediate time scales. The main cause of the hysteresis is the elastoplastic deformation of collagen fibrils in the leathery regime. We explore the variations of these nanomechanical properties in sets of unfixed hydrated collagen fibrils isolated from native chicken achilles tendon and compare it with collagen fibrils embedded in the natural tendon. AFM imaging in air with controlled humidity preserves the tissue's native water content and allows for high-resolution imaging the assembly of collagen fibrils beneath an approximately 5 to 10-nm-thick layer of the fluid components of the interfibrillar matrix. This sheds new light on the role of interfibrillar bonds, the mechanical properties of the interfibrillar matrix, and the biomechanics of native tendon.

BP 4.3 Thu 11:15 P

Optical Stretcher for Adherent Cells — •Alexander Janik[1], Tobias Neckernuss[1], Nathalie Neffgen[2], Jonas Pfeil[1], Mika Lindén[2], and Othmar Marti[1] — [1]Institute of Experimental Physics, Ulm University — [2]Institute of Inorganic Chemistry II, Ulm University

We have demonstrated a method to stretch adherent cells with a parallel laser beam to probe their mechanical properties. This contribution focuses on improvements of the setup as well as on interactions between cells and the illumination light. Progress has recently been made in the detection of the z position of the upper cell membrane, which is now achieved by tracking fluorescent beads on the cell. This yields a high z resolution and eliminates artefacts resulting from laser induced aberrations, which affect mainly detection rays entering the objective at small angles.

BP 4.4 Thu 11:15 P

Identifying malignant tissue using fs-Laser Induced Breakdown Spectroscopy (LIBS) and Neural Networks — •Elena Ramela Ciobotea, Christoph Burghard Morscher, Cristian Sarpe, Bastian Zielinski, Hendrike Braun, Arne Senftleben, and Thomas Baumert — Kassel Universität, Kassel, Germany

The problem of differentiating cancerous tissue from a healthy one is currently solved in the diagnostic process through microscopic imaging of stained biopsy sections by pathologists. During surgical removal of cancerous tissue oncological safety margins must be established to ensure the complete removal of the tumor without affecting much of the neighboring healthy tissue. For this purpose, on-site pathological analysis is done on freshly frozen, stained cuts which is time consuming. We investigate a new approach of minimizing the time of discrimination between malign and benign tissue by an in situ, non-contact spectroscopic analysis. In a proof of principle experiment, a plasma is generated by focusing an 800 nm femtosecond laser on the pathologic postoperative sample. The spectrum of plasma radiation contains information on the element composition of the ablated tissue. Since the recorded spectra are complex and full of information, neural networks are employed to find differences between malign and benign tissue with a high speed and accuracy. In this contribution we present the experimental parameters that allow for the best possible differentiation of some biological tissues through fs-LIBS by minimizing deviations between the measurements.

BP 4.5 Thu 11:15 P

Epigenetic relevance of quantum phenomena in DNA — •Mirko Rossini and Joachim Ankerhold — Institute for Complex Quantum systems and IQST, Ulm University, Germany

The behaviour of excited particles along the DNA strand inside a cell has been a topic of foremost interest in the field of biophysics in the last 20 years. On one hand, understanding how the dynamics of such particles can affect the geometry and structural properties of the DNA, locally or globally, can lead to new insights in the field of epigenetics [1]. On the other hand, the DNA strand itself has been analysed to explore its potential as a molecular conducting nano-wire.
With this poster we provide a description of different tight-binding models with dissipative background, exploring their population dynamics and coherence properties. The choice of the parameters for the models is taken to mimic some specific DNA sequences which are relevant in the epigenetic field of research. We provide then some experimental results which justify our interest in this topic and in this methods. Apart from single charge dynamics, we also consider excitonic dynamics in various DNA sequences, in particular with respect to charge separation and localization.

[1] E. R. Bittner, J. Chem. Phys. **125**, 094909 (2006).

BP 4.6 Thu 11:15 P

Swimming vesicles propelled by flagellated bacteria in membrane tubes — •Lucas Le Nagard[1], Aidan Brown[1], Alexander Morozov[1], Angela Dawson[1], Vincent Martinez[1], Margarita Staykova[2], and Wilson Poon[1] — [1]The University of Edinburgh, United Kingdom — [2]Durham University, United Kingdom

Recent simulation studies have predicted that giant unilamellar vesicles submitted to a collection of local internal forces should display enhanced fluctuations and a fascinating diversity of shape changes, from the formation of membrane tubes to deformations leading to vesicle division. Experimental investigation of those phenomena, based on the encapsulation of self-propelled particles or swimming bacteria into giant lipid vesicles, has only recently started. Such minimal systems can be used to study the interactions between an active suspension and a confining (deformable) boundary. They should also help deepen the understanding of biological processes where membrane deformation under local forcing is important. In this work, we encapsulate motile *Escherichia coli* bacteria in low-tension giant lipid vesicles. We observe that the bacteria apply local forces on the membrane, deforming it to generate membrane tubes reminiscent of those seen in eukaryotic cells infected by *Listeria monocytogenes*. Strikingly, these bacteria-enclosing tubes can propel the vesicles. We show that the propulsive force arises from a tight coupling between the bacteria's well-bundled flagella and the membrane tubes, which become rotating helices turning the initially passive vesicles into active micro-swimmers.

BP 4.7 Thu 11:15 P

Effect of Liquid-Liquid Phase Separation of Pol II on gene regulation — •Arya Changiarath Sivadasan and Lukas Stelzl — Johannes Gutenberg University, Mainz

Liquid Liquid phase separation(LLPS) plays an important role in the regulation of cellular processes. In particular, LLPS underpins the formation of localized nuclear hubs of RNAP II during the transcription of genes. Recent experimental studies revealed that the disordered Carboxy terminal domain (CTD) of the largest subunit of RNAP II, has a very strong tendency to phase separate. In our research, we are trying to understand the molecular basis of phase separation of RNAP II using multiscale molecular dynamic simulations. Our initial preliminary studies show the effects of temperature on CTD phase behavior and the influence of polymer length on critical temperature of phase separation. The results show that critical temperature increases with polymer length as expected. As a next step, we are interested in studying the phase separation of phosphorylated RNAP II and the effect of noise in the biochemical signaling on phase behavior. Moreover, we are also keen to understand the phase separation of a complex mixture of biomolecules such as CTD and RNA binding protein FUS. This would give insights into how the LLPS of CTD and other biomolecules regulates the transcription process in cells and will enable us to elucidate how the regulation of genes by LLPS is affected by noise.

BP 4.8 Thu 11:15 P

Bio-inspired Magnetic Nanoprobes For Subcellular Manipulation Studies in Single Cells — •Andreas Neusch[1], Iuliia Novoselova[1], Julia-Sarita Brand[1], Marius Otten[1], Matthias Karg[1], Michael Farle[2], Ulf Wiedwald[2], and Cornelia Monzel[1] — [1]Heinrich-Heine-University, Düsseldorf — [2]University of Duisburg-Essen, Duisburg

Cellular signals rely on characteristic temporal and spatial distributions of signaling molecules, but hitherto it is unclear which patterns trigger which cellular response. In recent years, Magnetogenetics emerged as an approach where magnetic nanoparticles (MNPs) and magnetic fields are used to spatially manipulate molecules to trigger cellular processes in order to mimic and study natural signaling patterns [Monzel et al. (2017), DOI: 10.1039/C7SC01462G]. Here, we compared two MNPs regarding their use as nanoagents of cellular functions. First, a bio-inspired semisynthetic nanoparticle - Magnetoferritin (MFt) - was chosen, which consists of the iron storage protein ferritin and a synthetic magnetic iron oxide core. MFt is genetically equipped with mEGFP for microscopic observation and bio-orthogonal targeting [Lisse et al. (2017), DOI: 10.1002/adma.201700189]. Furthermore, synthetic iron-oxide MNPs (synomag, micromod, Rostock) were studied. After examining basic properties, we assessed methods of transfer into cells and probed MNP manipulation in the cytoplasm. Using external magnetic fields, MNPs were spatially redistributed and kinetically analyzed. Our magnetic manipulation approach bears the perspective to achieve an understanding of how cell signals evolve.

BP 4.9 Thu 11:15 P

On the adhesion-velocity relation and multistability of the motile state of MDA MB 231 cells on fibronectin lanes — Christoph Schreiber[1], Behnam Amiri[2], •Johannes Heyn[1], Joachim Rädler[1], and Martin Falcke[2,3] — [1]Ludwig-Maximilians-Universität München (LMU), Fakultät für Physik, Geschwister-Scholl-Platz 1, 80539 München, Germany — [2]Max Delbrück Center for Molecular Medicine in the Helmholtz Association, Robert Rössle Str. 10, 13125 Berlin, Germany — [3]Dept. of Physics, Humboldt University, Newtonstr. 15, 12489 Berlin, Germany

Migration of eukaryotic cells is a fundamental process for embryonic development, wound healing, immune responses, and tumour metastasis. A universal observation is the well-known biphasic adhesion-velocity relation. There is, however, little quantitative understanding of how adhesion and intracellular forces control cell velocity. We study the motion of MDA-MB-231 cells on microlanes with fields of alternating Fibronectin densities to address this topic and derive a mathematical model from the leading-edge force balance and the force-dependent polymerization rate. It reproduces quantitatively our measured adhesion-velocity relation. All motion-related forces are controlled by adhesion and velocity, which allows motion even with higher Fibronectin density at the rear than at the front. At transitions between different Fibronectin densities, steady motion is perturbed which changes the front and rear velocity. We then discuss the role of the biphasic relation between retrograde flow velocity and friction force for transitions of motile states.

BP 4.10 Thu 11:15 P

Exploring quantum features of the brain with MRI — •Christian Kerskens[1] and David Lopez Perez[1,2] — [1]Trinity College Institute of Neuroscience, Trinity College Dublin, Ireland — [2]Institute of Psychology, Polish Academy of Sciences, Warsaw, Poland

Recent proposals to explore quantum gravity have shown that if any physical system can mediate locally the generation of entanglement between two quantum systems, then it itself must be non-classical. Here, we adopted this idea to explore non-classicality in the human brain. Thereby, we considered an unknown brain function as the mediator which may or may not entangle the proton nuclear spins of free-diffusible bulk water. The challenge was to find a nuclear spin preparation that, together with a physiological condition, could facilitate the creation of quantum entanglement. For the spin preparation, we took the complementarity between magnetization and the likelihood of entanglement into account. As a result, we used a highly de-phased and saturated signal for our entanglement witness protocol, which was based on a hybrid multiple quantum coherence sequence. For the physiological condition, we assumed that some brain rhythms may influence the order at tissue level. Remarkably, we witnessed entanglement in the brains of our volunteers, if and only if, they were awake. Its temporal appearance showed a rhythm resembling heartbeat-evoked potentials. This link to conscious awareness underpins that the non-classical mediator may be used and manipulated in conscious-related computation, ergo we found indication that brain computation is non-classical.

BP 4.11 Thu 11:15 P

Revisiting the quantum brain — •Christian Kerskens — Trinity College Institute of Neuroscience, Trinity College Dublin, Ireland

More than 30 years ago, Penrose's published his pioneering ideas about the quantum brain, which was back then based on the knowledge at the time. This work, which marked an interim high in the field, received severe criticism. Meanwhile, many scientific areas relevant for the understanding of brain processes have evolved enormously. However, reservations remain. Here, we put some of those new jigsaw pieces together. We review findings from physics, quantum information, nematic, active matter, neuroscience, psychology, and philosophy which, we believe, could guide us towards a quantum brain theory. Thereby, we intend not to present a completed theory. We are aware that some direct translation from quantum physics to biology will, at the time, not hold a critical debate. However, we argue that the problem may be down to an insufficient understanding of physics, which needs to be solved. Biology may guide us (remember electrodynamics) once more to find in-depth insight into fundamental physics. Therefore, we divide the findings into those which resemble quantum computing but which can't be explained theoretically and into those which violate classicality in cognition and consciousness. We conclude that the brain may mimic a real brain quantum computer, which could potentially be based on topological quantum computing.