BP 18: Biomaterials (joint session BP/CPP)

Time: Wednesday 15:00–17:30 Location: H15

Invited Talk BP 18.1 Wed 15:00 H15

Bottom-up molecular control of biomimetic hydrogels — •Kerstin G. Blank — Johannes Kepler University, Institute of Experimental Physics, Altenberger Str. 69, 4040 Linz, Austria

The development of biomimetic hydrogels has greatly facilitated fundamental studies aimed at understanding cellular mechanosensing and mechanotransduction processes. It is now widely accepted that cells sense the elastic and viscoelastic properties of their surroundings and respond to these properties via a range of different mechanisms. It is still unknown, however, how cells determine these material properties. Hydrogels are usually characterized as bulk samples while cells interact with these materials in a highly localized manner via specific receptor-ligand interactions. It is thus essential to adopt the cellular point of view and establish a link between microscopic and macroscopic material properties. Towards this goal, we utilize biomimetic hydrogels consisting of mechanically characterized synthetic polymers and extracellular matrix-inspired peptides that serve as physical crosslinks. Using selected examples, we show how crosslink thermodynamics, kinetics and mechanics as well as network topology affect the linear and non-linear viscoelastic properties of molecularly programmed hydrogels. In particular, we highlight that both individual crosslink properties and network topology affect network stress relaxation and show how molecular bond rupture correlates with bulk material failure. Our modular hydrogel system allows for tuning different parameters independently and thus serves as an excellent platform for disentangling the roles of different material properties on cellular responses.

BP 18.2 Wed 15:30 H15

The role of protein constriction in the fission of membrane tubes — •Russell Spencer and Marcus Müller — Georg-August Universität Göttingen, Institute for Theoretical Physics, 37077 Göttingen, Germany

Membrane remodelling, such as fusion and fission, is involved in a variety of basic, cellular processes. When unaided, the free energy barriers for such remodelling can be prohibitively high, so biological systems employ proteins as catalysts. This work investigates the influence of proteins, such as dynamin, which constrict membrane tubes in order to lower the barrier to fission. We are particularly interested in their role in double-membrane fission as it occurs in mitochondrial division. This work employs self-consistent field theory and utilizes the string method to find the Minimum Free Energy Path (MFEP) in order to determine the most likely pathway for the transition. In addition to lowering the free energy barrier, constriction of the tubes also affects the dominant transition pathway. This work explores the interplay between membrane tension and constriction and the effects that these influences have on fission mechanisms of single and double membrane tubes.

BP 18.3 Wed 15:45 H15

Rate-Independent Hysteretic Energy Dissipation in Collagen Fibrils — Robert Magerle, •Paul Zech, Martin Dehnert, Alexandra Bendixen, and Andreas Otto — Fakultät für Naturwissenschaften, Technische Universität Chemnitz, 09107 Chemnitz, Germany

Nanoindentation data measured with an atomic force microscope on hydrated collagen fibrils above the glass transition, display a rate-independent hysteresis with return point memory. It is caused by the interplay of elastoplastic deformation during tip indentation followed by elastocapillary recovery of the indent during tip retraction. This previously unknown energy dissipation mechanism dominates at slow indentation rates, where viscous friction is negligible. A generic hysteresis model, based on force-distance data measured during one approach-retract cycle, predicts the force (output) for arbitrary indentation trajectories (input). This model describes collagen fibrils' elastic as well as their dissipative nanomechanical properties with high fidelity for a large range of tip velocities and indentation amplitudes.

15 min. break

BP 18.4 Wed 16:15 H15

Partition complex structure arises from sliding and bridging — •Lara Connolley and Sean Murray — Max Planck Institute for Terrestrial Microbiology, Marburg, Germany

Chromosome segregation is vital for cell replication and in many bacteria is controlled by the ParABS system. A key part of this machinery is the association of ParB proteins to the parS-containing centromeric region to form the partition complex. Despite much work, the formation and structure of this nucleoprotein complex has remained unclear. However, it was recently discovered that CTP binding allows ParB dimers to entrap and slide along the DNA, as well as leading to more efficient condensation through ParB-ParB-mediated DNA bridging. Here, we use stiff polymer simulations to show how these properties of sliding and bridging can explain partition complex formation. We find that dynamic ParB bridges condense the DNA through the formation of two structures, hairpins and helices. In separate stochastic simulations, we show that ParB sliding accurately predicts the experimentally measured multi-peaked binding profile of Caulobacter crescentus, indicating that bridging and other potential roadblocks are sufficiently short-lived that they do not hinder ParB spreading. Indeed, upon coupling the two simulation frameworks into a unified sliding and bridging polymer model, we find that short lived ParB bridges do not hinder ParB sliding from the parS sites, and can reproduce the binding profile of ParB as well as the overall condensation of the nucleoprotein complex. Overall, our model clarifies the mechanism of partition complex formation and predicts its fine structure.

BP 18.5 Wed 16:30 H15

Single-chain and condensed-state behavior of hnRNPA1 from molecular simulations — •D. Janka Bauer[1], Lukas Stelzl[1,2], and Arash Nikoubashman[1] — [1]Institute of Physics, Johannes Gutenberg University Mainz, Germany — [2]Biocenter, Institute of Molecular Physiology, Johannes Gutenberg University Mainz, Germany

Intrinsically disordered proteins (IDPs) are essential components for the formation of membraneless organelles, which play key functional and regulatory roles within biological systems. These complex assemblies form and dissolve spontaneously over time via liquid-liquid phase separation of IDPs. Mutations in their amino acid sequence can alter their phase behavior, which has been linked to the emergence of cancer and neurodegenerative diseases. In this work, we study the conformations and phase behavior of a low-complexity domain of heterogeneous nuclear ribonucleoprotein A1 (hnRNPA1), using coarse-grained molecular simulations. We systematically analyze how the single-chain and condensed-state behavior are affected by the number of aromatic residues within the examined sequences. We find a significant compaction of the chains and an increase in the critical temperature with increasing number of aromatic residues within the IDPs. Both observations strongly support the hypothesis that aromatic residues play a dominant role for driving condensation, which is further corroborated by a detailed analysis of the intermolecular contacts. By establishing quantitative comparisons to the experimental phase behavior, we start to critically assess the reliability of coarse-grained IDP models.

BP 18.6 Wed 16:45 H15

Water flow elastography for minimal invasive surgery — •Paul Kalwa and Tilman Schäffer — University of Tübingen, Germany

Mechanical properties of tissue are of great interest for physicians to differentiate healthy from malign tissue, to determine the status or extent of a disease, and to investigate tissue ageing. The measurement of these properties is therefore a helpful tool for diagnosis. Many elastography techniques have been established and are used in medicine today. However, most of these techniques are not applicable in minimal invasive surgery (MIS), because there the size of probes is limited to a few millimeters and the handling is restricted. We introduce water flow elastography, a novel technique that benefits from a small and inexpensive probe. This technique uses a specialized probe to flow pressurized water against the sample surface, thereby inducing a local indentation. The volume of the indentation, which is measured with a flow meter, is used to quantify the Young's modulus with the help of finite element simulations. We measure the Young's modulus of silicone samples and porcine organs and validate the results with a commercial testing machine, finding agreement within 15 %. We also discuss the suitability of this technique for the determination of viscoelastic tissue properties and for the application in endoscopes for MIS in the future.

BP 18.7 Wed 17:00 H15

Turning the Corner on the Image Method in Linear Elasticity and Low-Reynolds-Number Hydrodynamics — •Tyler Lutz, Lukas Fischer, Sonja Richter, and Andreas Menzel — Institut für Physik, Otto-von-Guericke-Universität Magdeburg, Universitätsplatz 2, 39106 Magdeburg

In both linear elasticity and low-Reynolds-number hydrodynamics, extensions of the image method—familiar from elementary electrostatics—have been developed to deduce the displacement (resp. velocity) fields arising from point forces applied in the vicinity of a single, flat, infinitely extended boundary. In this work, we assess the applicability of these methods to domains described by multiple, mutually orthogonal boundaries in 2 and 3 dimensions. Already in the case of a single flat boundary, the necessary image forces depend on the specific boundary conditions considered; the images become progressively more complex as one goes from free-slip to no-slip and stress-free surfaces. By iterating the image method for forces near corners or edges, we explicitly show that this method fails to generate a self-consistent image if any more than one boundary is anything other than a free-slip surface. For the situations in which the image method may be successfully applied, we explicitly construct and survey the qualitative features of the point-force Green's function near corners.

BP 18.8 Wed 17:15 H15

Adsorption of laminin and cellular response of neurons and glial cells on ion implanted titania nanotube scaffolds — •Jan Frenzel[1,2,3], Astrid Kupferer[1,2], Mareike Zink[3], and Stefan G. Mayr[1,2] — [1]Leibniz Institute of Surface Engineering (IOM), Permoserstraße 15, 04318 Leipzig, Germany — [2]Division of Surface Physics, Department of Physics and Earth Sciences, Linnéstraße 5, 04103 Leipzig, Germany — [3]Research Group Biotechnology and Biomedicine, Department of Physics and Earth Sciences, Linnéstraße 5, 04103 Leipzig, Germany

Brain-machine interfaces are used in a wide spectrum of neuroscience, as for time-resolved sensing of neural activities and for tackling neurodegenerative diseases. Currently established cultivation platforms, including cellulose filters, often result in loss of long-term adhesion, rejection reaction and glial scarring or do not allow for electrical contact due to their insulating properties. As we demonstrate, ion implanted titania nanotube scaffolds (TNS) are a promising candidate to overcome these issues, since they combine a high biocompatibility with a sufficient large electrical conductivity. In our experiments, we explain how ion implantation induced changes of surface characteristics affect the adsorption of laminin and the viability and adhesion of neurons and glial cells. We link the hindered laminin adsorption due to implantation to the shrinkage of tube diameter and rise of zeta potential. The stable and high neuron viability on all TNS but suppressed glial cell formation of implanted TNS gives rise for a potential interface material. Funding by SMWK (100331694) is gratefully acknowledged.