BP 7: Poster Session I

Biomaterials and biopolymers, cytoskeleton, cell mechanics and tissue mechanics; FS controlling biological cells by ultrasound

Time: Monday 15:00–17:00 Location: P5

BP 7.1 Mon 15:00 P5

Eco-Friendly PEGylated Iron Oxide Nanoparticles for In Vitro Targeted Delivery and Controlled Release of Docetaxel in SK-OV-3 Ovarian Cancer Cells — •Romesa Soomro[1], Che Azurahanim Che Abdullah[1,2], and Halima Alem Marchand[3] — [1]1Biophysics Lab, Department of Physics, Faculty of Science, Universiti Putra Malaysia, 43300, Selangor, Malaysia — [2]2Cancer Research Lab, Institute of Bioscience, Universiti Putra Malaysia, 43300, Selangor, Malaysia — [3]3Department of Matériaux, Métallurgie, Nanosciences, Université de Lorraine, Nancy, France

Iron oxide nanoparticles were green-synthesized using oolong tea extract as a natural reducing and stabilizing agent. A Taguchi L9 design was applied to optimize reaction parameters and obtain stable nanoparticles with reduced hydrodynamic size. The optimized particles were PEG-coated to improve biocompatibility and subsequently loaded with docetaxel for targeted cancer therapy. Characterization using spectroscopy, diffraction, magnetic measurements, and electron microscopy confirmed successful synthesis and coating, with superparamagnetic behavior and particle sizes below twenty nanometers. Drug release studies showed sustained, pH-responsive release under acidic conditions. Cytotoxicity evaluation using SK-OV-3 ovarian cancer cells demonstrated high biocompatibility of PEG-coated nanoparticles and strong anticancer activity of the docetaxel-loaded system. The results indicate that green-synthesized PEGylated iron oxide nanoparticles provide a promising and sustainable platform for controlled anticancer drug delivery.

BP 7.2 Mon 15:00 P5

The Potential Impact of a Novel Chitosan-Titanium dioxide Nanoparticles against Hepatocellular Carcinoma in Rat Model — Omnia Ahmed Mohamed Elbakary[1], Eman Ibrahim Kandil[1], Sawsan Mohamed Elsonbaty[2], Shaimaa El-saied Mohamed[1], and •Nermeen Mohamed Elbakary[3] — [1]Faculty of Science, Biochemistry department, Ain Shams University, Cairo, Egypt — [2]Radiation microbiology department, National center for radiation research and technology, Egyptian Atomic Energy Authority, Cairo, Egypt — [3]Radiation biology department, National center for radiation research and technology, Egyptian Atomic Energy Authority, Cairo, Egypt

Hepatocellular carcinoma (HCC) the most common type of liver cancer, is the fifth most common malignant tumor type worldwide and the second leading cause of cancer-related death. This study investigates the potential therapeutic effects of novel chitosan-titanium dioxide nanoparticles (Cs-Ti NPs) against hepatocellular carcinoma (HCC) in a rat model. The experimental design included five groups: a healthy control group, a group administered with diethylnitrosamine (DEN) to induce liver carcinogenesis, a group treated with Cs-Ti NPs, a DEN group subsequently treated with 5-Fluorouracil (5-FU), and a DEN group treated with Cs-Ti NPs. DEN was administered orally at 20 mg/kg body weight five times weekly for six weeks to induce tumor formation. Therapeutic interventions with Cs-Ti NPs and 5-FU were applied post-induction. The study evaluated apoptotic markers (Bcl-2, Bax, p53, Caspase-3, Cytochrome C), signaling pathways (MAPK, ULK1, mTOR), and serum tumor markers (AFP, NF-κB, COX-2) via ELISA. Results are expected to elucidate the molecular mechanisms involved and assess the efficacy of Cs-Ti NPs in mitigating HCC progression, potentially offering a new nanotherapeutic avenue for liver cancer treatment.

BP 7.3 Mon 15:00 P5

Viscous and Plastic Energy Dissipation Processes of Native Collagen Fibrils in AFM-based Nanoindentation Measurements under Controlled Humidity — •Martin Dehnert, Paul Zech, Mario Zerson, and Robert Magerle — Fakultät für Naturwissenschaften, Technische Universität Chemnitz, Germany

Collagens, lipids, and water are among the major molecular components of connective tissue, yet surprisingly little is known about their interactions in vivo. Here, we use AFM-based nanoindentation experiments to measure the mechanical response of collagen fibrils to deformation under constant strain (relaxation) or constant stress (creep) at different humidity levels and at different deformation speeds. The measured data are evaluated using a power-law analysis, in which the detailed indentation history, including the different indentation velocities, is taken into account. An in-depth analysis reveals that the phenomena of stress relaxation and creep compliance can be described by a time-scaled power law. Furthermore, we show that energy dissipation is primarily caused by plastic deformation during tip indentation and can be quantified with the ductility index. This parameter can also be used for high-resolution imaging of connective tissues. The ductility index provides additional information about the nanomechanical changes in collagen fibrils during development, aging, and disease.

BP 7.4 Mon 15:00 P5

Cyanobacteria as biological actuators — •Paul Nieschwitz and Stefan Karpitschka — Department of Physics, Universität Konstanz, Germany

Filamentous cyanobacteria are highly resilient, light-responsive organisms whose robustness and availability makes them ideal candidates for building engineered living materials (ELMs), that can adapt to or be controlled by external cues.

Here, we present a simple actuator composed of entangled filament assemblies wrapped around elastic PDMS-pillars. Contraction of the network generates a net resultant force that deflects the pillars. By calibrating the compliance of the pillars, we quantify this force. Varying the actuator geometry, filament density and illumination conditions, allows us to characterize the force output and dynamic response of the actuator.

Without requiring the need for genetic modification or sophisticated culture conditions, this platform offers a simple and robust approach to create light-controlled biological machines.

BP 7.5 Mon 15:00 P5

LactiFilm: Hydrogel supported co-culture biofilms of lactobacilli and phytoplankton for sustainable production of lactic acid — •Carina Schneider and Regine von Klitzing — TU Darmstadt, 64289 Darmstadt, Germany

Lactic acid is an essential bulk chemical used across the food, pharma, and cosmetics industry. Recently, its demand has been rising as the monomer for synthesizing polylactic acid, a major biodegradable alternative to conventional plastic. Hence, biological synthesis of lactic acid offers a greener production option. In this work, we develop a biofilm-inspired strategy by immobilizing lactobacilli and algae in smart hydrogels.

The algae immobilization matrix is formed from crosslinkable PNIPAM (Poly N-Isopropylacrylamide) microgels containing the UV-sensitive comonomer HMABP (2-Hydroxy-4-(methacryloyloxy)benzophenone), enabling microgel crosslinking into a stable hydrogel film. Due to the volume phase transition temperature of PNIPAM, the matrix exhibits controllable swelling and deswelling behavior. This responsiveness allows for regulated partial lysis of the algae to release nutrients that support lactic-acid production. To assess the mechanical strength of the hydrogel, we perform atomic force microscopy (AFM) indentation measurements.

BP 7.6 Mon 15:00 P5

Multi-phase coexistence of charged condensates — •Chengjie Luo, Yicheng Qiang, and David Zwicker — MPI-DS, Göttingen, Germany

Biomolecular condensates are complex droplets whose formation is believed to be primarily driven by short-range attractive interactions between diverse molecules. However, charges that mediate long-range interactions can also strongly affect phase separation. Using a mean-field theory, we demonstrate that electrostatic interactions can drive rich phase separation behavior. In a simple system of three charged components, these interactions can lead to the coexistence of multiple phases, including homogeneous phases with different compositions and patterned phases with finite-sized droplets. Furthermore, applying an external electric field can dramatically alter these coexistence states:

weak fields cause charged droplets to move like colloidal particles, while stronger fields stretch droplets, leading to the formation of striped patterns. Our work establishes electrostatics and electric fields as potent controllers of phase coexistence, with implications for understanding biological condensates and designing synthetic patterned materials.

BP 7.7 Mon 15:00 P5

Density and viscosity Measurements of the cytosol of human red blood cells — •Thomas John, Karin Kretsch, and Christian Wagner — Experimental Physics, Saarland University

We present a method to determine the viscosity of the intracellular liquid - the cytosol - of human red blood cells (RBCs). Our method combines the measurement of the mass density distribution of RBCs and the viscosity of the cytosol as a function of the water content. The density distribution is measured through buoyant density centrifugation combined with cell counting. By correlating this distribution of cell population densities with the viscosity-density relation of the cytosol, we obtain a log-normal distribution of the cytosol viscosity of healthy RBCs. The viscosity contrast λ, defined as the ratio of viscosities between the RBC cytosol and the blood plasma under physiological conditions, is determined to have a log-normal distribution with a mean value of $\bar{\lambda} = 10$. This value is significantly larger than those used in the literature for numerical simulations. The wide distribution of the viscosity values results from the loss of a small amount of water from the RBCs over their 120-day lifespan. We find that the viscosity of the cytosol in older cells is more than twice as high as in younger cells, a fact that should be taken into account in future theoretical investigations.

BP 7.8 Mon 15:00 P5

Model particles to study interaction of microplastic particles — •Kai Gossen, Andreas Fery, and Günter Auernhammer — IPF Dresden, Dresden, Germany

Microplastic in the environment is typically coated by natural organic matter forming an ecocorona. We present an approach to model ecocorona on parti- cles with well-defined polymers, synthetic and derived from natural polymers. Polystyrene particles were coated with fluorescent polyelectrolyte multilayer systems, PS(Chitosan/Hyaluronic acid) and PS(Poly(dimethyldiallylammonium chloride) /Polystyrene sulfonate) by the layer-by-layer method. Systems with 2, 4 and 6 bilayers were synthesized. The second layers were fluorescently labelled with SNARF conjugated dextran. It was found that zeta potentials of the PS(Chi/HS)2/4/6 systems assume val- ues (-20 mV to -35 mV) that are similar to those of PS-ecocorona particles (-40 mV to -5 mV). The pH-dependent fluorescence of particle suspensions and indi- vidual particles were measured at pH values between pH 3 and pH 8. A well mea- surable pH dependence between pH 4.5 and 8 for the PS(Chi/HS) systems and the PS(PDADMAC/PSS) system could be measured. Automating particle synthesis via cross-flow filtration produces particle batches of up to 5 g. The system could serve to selectively study effects of surface properties of ecocorona coated particles such as surface stiffness or zeta potential.

BP 7.9 Mon 15:00 P5

Controlled Spray coating of Bacterial Nanocellulose Thin films revealed by Surface-Sensitive X-ray Scattering — •Joanne Neumann[1], LI Li[2], Edina Klein[1,3], Jan Rubeck[1], Ute Römling[2], Holger Sonderrmann[1,3], and Matthias Schwartzkopf[1] — [1]DESY, Photon Science, Notkestr. 85, D-22607 Hamburg — [2]Department of Microbiology, Tumor and Cell Biology, Biomedicum, KI, Karolinska Institutet, Nobels väg 6, S-17177 Stockholm — [3]CSSB, Center for Structural Systems Biology, Notkestr. 85, D-22607 Hamburg

Bacterial nanocellulose (BNC) is a sustainable biomaterial valued for its purity, nanoscale fibrillar structure, and biocompatibility. Its properties can be tailored through genetic engineering, growth conditions, and processing. Here, we fabricate thin films from BNC produced by *S. typhimurium*, *Komagataeibacter*, and *Klebsiella* using airbrush spray deposition of aqueous dispersions as a green, reproducible method. We examine how different extraction procedures (acidic, alkaline, surfactant-based) affect nanoscale organization and film adaptability. High-resolution X-ray scattering (μGIUSAXS/μGIWAXS) is used to probe fibril orientation, aggregation, and hierarchical ordering. Our results show extraction-dependent structural variations that influence film homogeneity and functional performance. By refining spray-coating and scattering protocols, this work links chemical treatment history to structural adaptability and supports sustainable strategies for controlled BNC thin-film fabrication in materials science and bioengineering.

BP 7.10 Mon 15:00 P5

Engineering Shear-Thinning Hydrogels: A Dynamic Scaffold for 3D Tissue Culture — •Bruno Schmelz[1], Fen Li[2], Kai Zhang[2], and Timo Betz[1] — [1]Third Institute of Physics, University Göttingen — [2]Sustainable Materials and Chemistry, University Göttingen

Extracellular matrix scaffolds are essential for advanced 3D cell culture systems, providing structures for cell movement as well as physical and chemical cues that promote migration, proliferation, and differentiation. Hence, the extracellular matrix is crucial for functional tissue formation. However, natural extracellular matrix materials used in vitro, such as collagen and elastin, are difficult to control regarding elastic properties, polymer mesh size, and homogeneity. Our objective is to design a dynamic hydrogel, tailored to meet the specific requirements of 3D tissue culture, such as viscoelastic properties and cell-binding sites, that initially supports tissue formation but can be dissolved and replaced by cell-generated extracellular matrix. We propose a hydrogel with dynamic cross-links that allows for reorganization by embedded cells, resembling processes in physiological tissues. We present the rheological properties of the hydrogel and the initial findings of cellular migration and reorganization of cell-gel systems. When subjected to stress, the hydrogel exhibits a transition to a more liquid-like state, with the potential to solidify again upon stress relaxation. This behavior allows cells to remodel their surrounding matrix and shape their environment, as evidenced by experiments with cells cultured in the hydrogels.

BP 7.11 Mon 15:00 P5

Atomic-Scale Probing of Aluminum Distribution in Catalysts and Peptide COM Fidelity — •Sakshi Sinha — Department of Materials Physics, Institute of Material Science, University of Stuttgart, Heisenbergstr. 3, 70569 Stuttgart

Atom Probe Tomography (APT) enables three-dimensional, atomic-scale mapping of inorganic and biomolecular materials. Using conventional lift-out specimen preparation, we study aluminum distribution in microporous aluminosilicate catalysts with varying Al content. The frequency distribution with considering different sphere sizes N in order to investigate size-dependent effects for segregating or clustering behavior of the Al atoms. APT reveals atomic-scale clustering and uniformity of Al, providing direct insight into acid site density and strength, and complements bulk techniques such as ICP-OES by resolving localized compositional variations. For biomaterials, cryogenic quench-freezing is used to prepare aqueous specimens. Mass spectra indicate that fragmentation behavior is concentration-dependent and influenced by hydration shell disruption during field evaporation. Experimental interfragment distances closely match theoretical center-of-mass distances within 1 Å, demonstrating that APT can preserve biomolecular subunit spatial relationships with sub-angstrom fidelity. These studies demonstrate the versatility of APT in probing both inorganic and biomolecular systems with unprecedented atomic precision, opening pathways for understanding structure*function relationships across material classes.

BP 7.12 Mon 15:00 P5

Decoupling Crosslink Stability and Network Connectivity in Coiled Coil Crosslinked Hydrogels — Stefanie Lenzeder[1], Geonho Song[1,2], Isabell Tunn[2], Alberto Sanz de Leon[2], Tanja D. Singewald[1], and •Kerstin G. Blank[1,2] — [1]Johannes Kepler University, Linz, Austria — [2]Max Planck Institute of Colloids and Interfaces, Potsdam, Germany

Biomimetic hydrogels serve as a powerful platform for investigating how cells sense and respond to the mechanical cues in their environment. Despite significant progress, the precise mechanisms how cells evaluate the elastic and viscoelastic properties of their surroundings remain incompletely understood. While hydrogels are typically characterized based on their bulk material properties, cells probe these materials on the molecular scale through receptor-ligand interactions. Bridging the gap between molecular-scale interactions and macroscopic material behavior is thus essential for advancing our understanding of cell-material interactions. Inspired by proteins found in the extracellular matrix, we are investigating biomimetic hydrogels crosslinked with coiled coil forming peptides. These modular building blocks enable precise control over their molecular characteristics, such as thermodynamic, kinetic and mechanical stability as well as oligomerization

state. Our findings show that the bulk material properties are governed more strongly by network connectivity than crosslink stability. These insights deepen our understanding of how molecular design impacts the macroscopic behavior of hydrogels, opening new avenues for tailoring materials for specific biological applications.

BP 7.13 Mon 15:00 P5

Development and investigation of coarse-grained particle models for alginates. — •Hensi Gandhi, Rudolf Weeber, and Christian Holm — Institute for Computational Physics, University of Stuttgart, Stuttgart, Germany

Alginates form ion-mediated gel networks whose mesoscale structure and mechanical properties depend on monomer sequence, charge distribution, and environmental conditions. We aim to develop coarse-grained models that capture these molecular features while remaining computationally efficient. Our ongoing work combines all-atom molecular dynamics with systematic coarse-graining to derive bonded interactions, electrostatics, and ion-mediated cross-linking rules. The models will be implemented in ESPResSo [1] using implicit solvent, with extensions for multivalent ions and shear via Lees Edwards or lattice Boltzmann coupling. We will study how monomer sequence, salt concentration, and pH influence chain flexibility, persistence length, gelation kinetics, and network topology, and compare structural and mechanical observables with experiments to assess model transferability. This framework is intended to support mesoscale predictions within the GRK SusGel program [https://www.susgel.kit.edu/24.php] and link molecular design to macroscopic gel properties.

[1] F. Weik, R. Weeber, K. Szuttor, K. Breitsprecher, J. de Graaf, M. Kuron, J. Landsgesell, H. Menke, D. Sean, C. Holm, ESPResSo 4.0 - An extensible software package for simulating soft matter systems, European Physical Journal-Special Topics, 227 (2019), 1789-1816, DOI: 10.1140/epjst/e2019-800186-9.

BP 7.14 Mon 15:00 P5

Cytoskeletal Networks in 3D Cysts Under Strain — •Greta Höhndorf[1], Ruth Meyer[1], Ruben Haag[1], Ulrike Rölleke[1], Ulla Unkelbach[2], Nicole Schwarz[3], Andreas Janshoff[2], and Sarah Köster[1] — [1]Institute for X-Ray Physics, University of Göttingen — [2]Institute of Physical Chemistry, University of Göttingen — [3]Institute of Molecular and Cellular Anatomy RWTH Aachen University

The cytoskeleton of eukaryotic cells mainly consists of actin filaments, microtubules and intermediate filaments (IFs). Unlike actin and microtubules, IFs are cell-type specific. Epithelial cells express keratin IFs, which form a layer close to the membrane in certain cell types. This layer is referred to as the "IF-cortex" and is hypothesized to adopt a "rim-and-spokes" structure with radial spokes supporting mechanotransduction properties of the cell. This structure raises questions about how the actin and IF cortices complement each other and how the mechanical properties of keratin influence force transmission in cells under high strain. To address these questions, we show a 3D approach where epithelial cells form polarized cysts and are stretched by injecting mineral oil into the lumen. When comparing wild-type (WT) and keratin knock-out (KO) cysts, we find that KO cysts deform more easily at low strains and respond more sensitively at high strains than WT cysts, indicating a stabilizing role of keratin under increased mechanical load. Furthermore, by staining actin, keratin, and the nuclei and performing fluorescence imaging pre and post stretching, we investigate strain dependent network changes and deformations.

BP 7.15 Mon 15:00 P5

Interactions between single actin and vimentin filaments — •Pallavi Kumari[1], Kristian Pajanonot[1,2], Komal Bhattacharyya[2], Stefan Klumpp[2], and Sarah Köster[1] — [1]Institute for X-Ray Physics, University of Göttingen, Germany — [2]Institute for the Dynamics of Complex Systems, University of Göttingen, Germany

The cytoskeleton plays a crucial role in maintaining cellular structure, mechanics, and function. Recent advances suggest that the diverse tasks of the eukaryotic cytoskeleton depend on the interactions between its filamentous components–microtubules, actin filaments, and intermediate filaments. Despite a growing number of studies aimed at a better understanding of these interactions, it remains unclear whether actin and intermediate filaments interact directly in the absence of an auxiliary protein. Previous *in vitro* studies on reconstituted mixed filament networks have reported inconclusive results. To clearly resolve this inconclusiveness, it is essential to further simplify the system down to the single filament level. Here, we present a study on the direct interactions between actin and vimentin intermediate filaments at the single filament level. Using quadruple optical tweezers combined with confocal microscopy and microfluidics, we precisely control the interaction conditions, visualize the interactions in real time, and measure the forces involved. Our research provides direct evidence of actin-vimentin interactions, together with a quantification of the interaction forces they exert on each other.

BP 7.16 Mon 15:00 P5

Mechanical Properties of Intermediate Filament Networks — •Jonas Penning, Komal Bhattacharyya, and Stefan Klumpp — Institut für Dynamik komplexer Systeme, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

The mechanical strength and dynamics of cells are essential for sustaining life. For instance, during simple activities such as breathing or walking, cells experience significant tensile stresses as they are stretched, sheared, or compressed. The cytoskeleton - a cross-linked composite network of actin, microtubules, and intermediate filaments - plays a central role in determining the cells' mechanical properties. This work focuses primarily on intermediate filaments, with particular emphasis on vimentin. Compared to actin, intermediate filaments exhibit much smaller persistence lengths, but are much more stretchable with highly nonlinear elasticity. A simplified, lattice-based model of fibrous networks with variable connectivity has been developed to investigate the mechanical and physical properties of such vimentin filament networks, as the model allows for the corresponding nonlinear behavior of individual vimentin filaments under strain. Analogous to experimental approaches, the mechanical properties of the model are tested by applying normal and shear strains or stresses and analyzing the resulting responses. Stretching the networks isotropically and comparing linear and nonlinear strain-behavior of individual filaments, the model shows an internal energy decrease for nonlinear elasticity and a strain-softening quantified by a turning point in the bulk modulus with increasing network-strain.

BP 7.17 Mon 15:00 P5

Phosphorylation-induced softening of vimentin networks revealed by optical tweezers microrheology — •Yuzhen Feng, Shanay Zafari, and Sarah Köster — Institute for X-Ray Physics, University of Göttingen, Germany

Phosphorylation is a key post-translational modification regulating intermediate filament (IF) organization and cell mechanics. While phosphorylation-induced softening of single vimentin filaments has been reported, its impact on network-level mechanics remains unclear. Here, we employ optical tweezers-based active microrheology to quantify the mechanical properties of vimentin IF networks containing defined fractions of the phosphomimetic vimentin mutant S72E. Both unmodified and phosphomimetic vimentin networks exhibit a viscoelastic response with partial stress relaxation after deformation. Increasing the phosphomimetic content reduces the overall stiffness, indicating phosphorylation-induced softening at the network level. These findings extend the understanding of how biochemical regulation at the molecular level translates into mechanical remodeling of IF across scales from the single-filament to the network level.

BP 7.18 Mon 15:00 P5

Microtubule networks exhibit amorphous material behavior — •Claudia Marcelli[1], Raffaele Mendozza[2], Shanay Zafari[1], Ruben Haag[1], Peter Sollich[2], and Sarah Köster[1] — [1]Institute for X-Ray Physics, University of Göttingen, Germany — [2]Institute for Theoretical Physics, University of Göttingen, Germany

Microtubules (MTs), together with intermediate filaments and actin, are the main components of the cytoskeleton. Among these filaments, MTs are the stiffest. They can form a rigid cellular scaffold and transmit forces across the cell while remaining extremely dynamic and able to assemble into specific cell structures (e.g. mitotic spindles). While MTs have been extensively characterized at the single-filament level, it is still not fully resolved how they collectively behave at the network-scale level. Here, we present a comprehensive characterization of the linear and nonlinear mechanical responses of stabilized MT networks at the microscale by using optical tweezers. To this aim, we employ both strain-ramp and large-amplitude oscillatory strain protocols, applying a range of deformations that allows us to probe both regimes. Our results show that MTs can withstand high stress and behave as an amorphous material, exhibiting a yielding transition from an elastic response at small strains to a viscous response at large strains.

These findings provide us with a deeper understanding of the mechanics of MT networks while setting the stage for future studies in which dynamic or active elements can be incorporated into the network to understand how activity modifies material mechanical properties.

BP 7.19 Mon 15:00 P5

MatrixModel: Building a Computational Model of the HSPC niche — •Julia Käsehagen and Sophia Rudorf — Institute for Cell Biology and Biophysics, Leibniz Universität Hannover, Germany

Haematopoietic stem and progenitor cells (HSPCs) rely on finely tuned adhesion to extracellular matrix (ECM) proteins within the bone marrow niche to balance quiescence, self-renewal, and differentiation. As part of the research consortium Matrix Evolution [1], MatrixModel develops a multiscale computational framework to predict how ECM composition, architecture, and mechanics regulate HSPC behavior, including adhesion and motility. We implemented two pipelines to use and adapt models by other goups: (i) a mechanochemical ODE model of integrin-talin-vinculin adhesion dynamics (by Honasoge et al. [2]) and (ii) a hybrid Cellular-Potts-Bead-Spring model of ECM fiber networks (by Tsingos et al. [3]).

For (i), we will parameterize the ODE model for HSPCs to predict adhesion lifetimes and tractions per adhesion. In (ii), the Cellular-Potts-Model (CPM) governs HSPC shape and contract energies, while a nonlinear fiber network captures density, crosslinking, and anisotropy. Cell-fiber links inherit rate laws from results of the ODE model.

[1] https://www.cell.uni-hannover.de/en/research/main-research-areas/matrix-evolution
[2] Honasoge et al., 2023, PLoS Comput Biol.
[3] Tsingos et al., 2023, Biophysical Journal.

BP 7.20 Mon 15:00 P5

Stiffness Characterization of Microtentacles: an optical tweezers study — •Kirill Korneev[1], Thomas John[1], Franziska Lautenschläger[1,2], and Christian Wagner[1,2] — [1]Department of Experimental Physics, Saarland University, Saarbrücken, Germany — [2]Center of Biophysics, Saarland University, Saarbrücken, Germany

Laser tweezers (LT) are devices used for manipulating, trapping, and measuring forces on particles within optical traps, and they are commonly used in biophysics. Microtentacles (McTNs) are membrane protrusions supported by bundles of microtubules produced inside cells. These McTNs appear in circulating tumor cells and are thought to play a key role in facilitating the cells adhesion and extravasation process from the blood vessel. Although the biological mechanisms underlying McTN formation have been partially characterized, their characterization by physical material parameters is still lacking. The objective of this work is to study the deformation of McTNs using optical trap force measurements. We will show how McTNs behave under the action of external forces in the piconewton range and suggest a method to extract their Young's moduli

BP 7.21 Mon 15:00 P5

Determination of the Human Red Blood Cell Mass Density Distribution — •Luca Hastenteufel[1], Thomas John[1], Karin Kretsch[1], and Christian Wagner[1,2] — [1]Dynamics of Fluids, Experimental Physics, Saarland University, 66123 Saarbrücken, Germany — [2]Physics and Materials Science Research Unit, University of Luxembourg, L-1511 Luxembourg, Luxembourg

Red blood cells (RBCs) survive in circulation for approximately 120 days, during which their mass density increases, leading to the formation of a density distribution (DD). This distribution is commonly used as a diagnostic marker and as an indicator of individual cell age. However, few studies have examined the detailed form of the DD, with only few datapoints. In this study, the DD of erythrocytes was quantitatively derived using microscopic imaging approaches in controlled linear density gradients. Linear gradients were created using Percoll and Optiprep, common density media used for the density separation of cells or subcellular compounds. A custom microscopic scanning setup was developed to image RBC distributions along the gradient with a micrometre spatial resolution over several cm. Through image analysis, the vertical positions of individual cells were detected and by single cell counting, the DD was constructed in high resolution. The measured DD revealed significant deviations from Gaussian behaviour.

BP 7.22 Mon 15:00 P5

Integration of environmental stimuli into the contraction dynamics of *Physarum polycephalum* — •Nora Deiringer and Karen Alim — School of Natural Sciences, Technical University of Munich, Garching, Germany

In many organisms, behaviour and decision-making are guided by environmental stimuli. However, the internal dynamics linking stimuli to behaviour are often complex and not fully understood. Additionally, an organism's response to a stimulus can depend on its past stimulus history. In the unicellular, network-shaped organism *Physarum polycephalum*, migration results from the redistribution of cell mass driven by self-organised rhythmic tube contractions. In this study, we mimic environmental stimuli by exposing the cell's contraction dynamics to patterns of harmful blue light. Through live recordings, we observe the imprints of these patterns in the cell's dynamics and investigate how dynamic stimulus memories arise and decay. By varying the time span between two consecutive stimuli, we aim to elucidate how past stimulus history influences responses to future ones. Our findings provide insight into the mechanisms by which simple, non-neural organisms can organise adaptive behaviour.

BP 7.23 Mon 15:00 P5

Coordination of Migration by Adaptive Mechanics — •Diana Lenski, Lucas Troeger, and Karen Alim — School of Natural Sciences, Technical University of Munich, Germany

Unicellular organisms navigate and adapt to their environment using characteristic migration strategies, among them chemotaxis, the ability to detect and respond to chemical gradients. Although numerous models exist for amoeboid migration, the mechanisms governing directional sensing and movement in dynamical systems with complex morphologies across various size scales remain partially characterised. Besides continuous locomotion, migration strategies can involve dynamic regulatory phases that modulate the migratory behaviour. One such example in the slime mould *Physarum polycephalum* are stationary oscillations that repeatedly interrupt persistent migration.
This project involves the analysis and modelling of experimentally observed stationary oscillations in *P. polycephalum* across macroscopic and intermediate scales. These oscillations manifest as the periodic, opposing formation of protrusions that define the direction of migration, making them a key observable across spatial and temporal scales. First, we will statistically evaluate the chemotactic efficiency of large and small plasmodia on the macroscopic scale. Subsequently, we will examine oscillation dynamics by tracking contraction patterns to evaluate their contribution to migration phases and energy efficiency.
Integrating both perspectives will provide a deeper understanding of oscillatory migration phases as a fundamental element of amoeboid migration strategies.

BP 7.24 Mon 15:00 P5

Deep learning architecture combining Vision Transformers and U-Nets for robust traction force microscopy — •Yunfei Huang[1], Elena Van der Vorst[2,3], and Benedikt Sabass[1,2,3] — [1]Faculty of Physics, Technical University Dortmund, Dortmund, 44227, Germany — [2]Faculty of Physics and Center for NanoScience, Ludwig Maximilian University of Munich, Munich, 80752, Germany — [3]Department of Veterinary Science, Ludwig Maximilian University of Munich, Munich, 80752, Germany

Traction force microscopy (TFM) quantifies cellular forces on the extracellular matrix. Although deep learning has advanced TFM analysis, challenges remain in achieving reliable inference across spatial scales, estimating uncertainty, and integrating biological information such as cell type. In this study, we propose a robust deep learning architecture, ViT+UNet, which integrates a U-Net with a Vision Transformer. Our results show that this hybrid model outperforms either U-Net or ViT alone in predicting traction force fields. In addition, ViT+UNet achieves superior generalization across a wide range of scales, which allows one to use the algorithm for TFM with different setups and equipment. We extend the model with an uncertainty estimation module that enables simultaneous prediction of traction forces and confidence levels. Incorporating cell-type information further improves accuracy. Simulated results show that the algorithm effectively reconstructs 3D traction fields in non-linear elastic matrices.

BP 7.25 Mon 15:00 P5

Identifying the proteins controlling the intracellular active mechanics — •Noemie Veyret, Till Muenker, and Timo Betz — Third institute of Physics, University of Göttingen, Germany

Over the past few years, the study of cell mechanical properties has allowed new insights on the understanding of biological processes and life

complexity. According to previous work, intracellular mechanical properties can be narrowed down to a fingerprinting of only 6 parameters. Through the use of active and passive microrheology measurements via optical tweezers, frequency dependent viscoelastic properties and intracellular activity were found to vary for different cell types. The aim of this project is to find a correlation between changes in protein expressions and mechanical fingerprint of cells. To do so optical tweezers measurements will be performed during the differentiation process of induced Pluripotent Stem Cells (iPSC) into different cell types such as skeletal muscles or cardiac fibroblasts. This measurement allows the characterization of the mechanics during the iPSC differentiation process. In parallel, the cell proteome will be studied using mass spectroscopy. Combining both, we hope to find the connection between proteins and their mechanical role, the intracellular "mechanome".

BP 7.26 Mon 15:00 P5

Characterization of filamentous cyanobacteria using force-sensing micropipettes — •Paul Dufke and Stefan Karpitschka — Fachbereich Physik, Universtität Konstanz

Filamentous cyanobacteria strongly influence nearly all ecosystems, sometimes with harmful impacts. It is believed that their dominance is based on collective traits such as aggregation, entanglement and dispersal, but the details remain elusive. To understand the collective behaviour that arises in ensembles of many filaments, it is necessary to quantify the mechanical properties of individual filaments. We characterize their bending stiffness using force-sensing micropipettes with nanonewton resolution, quantifying three different species across various growth stages, which affect the filament diameter and thus their bending stiffness. The observed diameter dependence of the bending modulus suggests that most of the structural rigidity emerges from a thin region near the cell wall. The connection between culture age and mechanical properties indicates that modulations of flexural rigidity may also influence the collective behaviour at different stages in the life cycle of a colony.

BP 7.27 Mon 15:00 P5

Passive vs active shells: from spectrin to actin cortex — •Tim Kutz[1], Bart Vos[1], Bart Jan Ravoo[2], Andreas Janshoff[3], and Timo Betz[1] — [1]Third Institute of Physics, Georg August Universität Göttingen, Göttingen, Germany — [2]Institute of Physical Chemistry, Georg August Universität Göttingen, Göttingen, Germany — [3]Organic Chemistry Institute and Center for Soft Nanoscience, University of Münster

The viscoelastic and tensile properties of the cell surface are key regulators of processes such as migration, division, and shape control, yet the respective roles of membrane and cortex remain only partially understood. Here, we use a combined experimental approach integrating atomic force microscopy (AFM) and micropipette (MPA) aspiration to dissect surface mechanics in two paradigmatic systems: red blood cells (RBCs) and Xenopus tadpole cells (XTCs). RBCs provide a membrane-dominated reference state with a passive spectrin network, while XTCs feature an active actomyosin cortex coupled to the plasma membrane. AFM-based tether pulling and creep compliance measurements yield local effective tension and viscoelastic response, whereas MPA reports global surface tension and large-scale deformation behaviour. From the combined data, we identify clear differences in relaxation behavior and tension build-up between RBCs and XTCs, reflecting the presence of active contractile elements in the cortex. Our results demonstrate how multi-modal micromechanical probing can disentangle membrane- versus cortex-dominated contributions to cell surface tension.

BP 7.28 Mon 15:00 P5

Deciphering the role of flagellar membrane glycoproteins in ciliary adhesion of *Chlamydomonas reinhardtii* — •Lea Rupprecht[1], Adrian Nievergelt[2], Rodrigo Catalan[1], Lara Hoepfner[3], and Oliver Bäumchen[1] — [1]University of Bayreuth, Experimental Physics V, 95447 Bayreuth, Germany — [2]Max Planck Institute of Molecular Plant Physiology, 14476 Potsdam, Germany — [3]Human Technopole, 20157 Milan, Italy

Elucidating the physical mechanisms of microbe-surface interactions is essential for developing novel technologies to control the formation of microbial biofilms. While most studies focus on bacteria as model systems, the adhesion of eukaryotic photosynthetic microorganisms to surfaces remains rather elusive. *Chlamydomonas reinhardtii* has been shown to adhere to surfaces with its two cilia under blue light [1], yet the underlying molecular mechanism remains unclear. For decades, the N-glycosylated proteins FMG1-B were considered the main adhesive components of the ciliary glycocalyx, with FMG1-A also contributing to its organization and function. We performed *in vivo* single-cell micropipette force spectroscopy [2] and adsorption/desorption [3] experiments on CRISPR/Cas9-generated FMG1-B-, FMG1-A-, and double-knockouts of *C. reinhardtii*. Thereby we examine how the absence of specific glycocalyx components affects ciliary adhesion forces in different light conditions.

[1] Kreis *et al.*, *Nature Physics* **14**, 45-49 (2018).
[2] Backholm and Bäumchen, *Nature Protocols* **14**, 594-615 (2019).
[3] Catalan *et al.*, *Soft Matter* **19**, 306-314 (2023).

BP 7.29 Mon 15:00 P5

Probing the micromechanics and fluidity of cellular spheroids — •Tom Sosniok[1], Antoine Girot[1], Gabriel de Barros Righes[2], Rodrigo Catalán[1], Ada Cavalcanti-Adam[2], and Oliver Bäumchen[1] — [1]University of Bayreuth, Experimental Physics V, 95447 Bayreuth, Germany — [2]University of Bayreuth, Cellular Biomechanics, 95447 Bayreuth, Germany

Characterizing the mechanical properties of multicellular spheroids is crucial to elucidate the dynamics of biophysical processes such as pathological tissue development, tumor metastasis and disease progression. Spherical cellular aggregates often serve as valuable tissue models, yet, they cannot be readily characterized with conventional techniques that are optimized for single cells. By combining micropipette force spectroscopy [1] with optical shape tracking, we provide an experimental approach to measure the mechanical properties of spheroids. Here, we first applied this technique to the model organism *Volvox globator*, a photosynthetic microbe that naturally forms spherical aggregates. We show that the compression and relaxation dynamics of *Volvox* can be described by a viscoelastic model, with the viscous component exhibiting a shear-thinning behaviour that is accurately described by a power-law fluid. We find that the viscoelasticity of the aggregates as well as their elastic modulus depend on their life stage. Finally, we applied the same methodology and modelling to aggregates of human colorectal adenocarcinoma cells with epithelial morphology and analysed their mechanical properties.

[1] M. Backholm and O. Bäumchen, *Nat. Protoc.* **14**, 594 - 615 (2019).

BP 7.30 Mon 15:00 P5

Intracellular mechanics in migrating cells — •Jannis Fischer[1], Mohammad Amin Eskandari[1], Sarah Louisa Lädke[1], Till Moritz Münker[1], Matthias Krüger[2], and Timo Betz[1] — [1]Third Institute of Physics, Göttingen, Germany — [2]Institute for Theoretical Physics, Göttingen, Germany

To fulfill their incredibly large number of different tasks, biological cells have developed mechanisms to adapt their physical properties and appearance, for example cell shape variation or cell migration. It is still not clear whether the changes in these mechanical properties are due to passive or active processes. Investigating and understanding these processes is the core of this work. For this, I will analyze the behavior of migrating cells, which are induced to move alternately on adhesive patterns. To connect the observed dynamics with the underlying mechanical properties and activities, I will use the new quantity of mean back relaxation (MBR). This can not only overcome the low throughput of optical tweezers, but also determine activity and mechanical properties through purely passive observations. With the MBR, we want to answer the question of how cellular shape influences mechanical properties.

BP 7.31 Mon 15:00 P5

Passive microrheology reveals anisotropic intracellular activity — •Sarah Louisa Lädke[1], Till Moritz Münker[1], Matthias Krüger[2], and Timo Betz[1] — [1]Third Institute of Physics - Biophysics, Georg August Universität Göttingen — [2]Institute for Theoretical Physics, Georg August Universität Göttingen

To investigate intracellular activity and the associated deviations from thermodynamic equilibrium, we study the fluctuations of endogenous vesicles and phagocytosed beads in various cell types and conditions. Experimentally, we combine darkfield microscopy with high-speed imaging and advanced image post-processing techniques, enabling the acquisition of trajectories with spatial and temporal resolution in the order of nanometers and milliseconds, respectively. We apply a novel observable, termed Mean Back Relaxation (MBR) [Münker et al., Nature Materials, 2024], to these trajectories. The MBR quantifies non-equilibrium in confined systems and establishes a link between intracellular particle fluctuations and their effective energies.

In doing so, we aim to extend the principles of passive microrheology to non-equilibrium environments. The MBR derived from our trajectories breaks time-reversal symmetry and exhibits pronounced anisotropies, indicating not only heterogeneous cellular structures but also anisotropic activity.

BP 7.32 Mon 15:00 P5

Forces in oocyte deformation analyzed via shear flow deformability cytometry — •Merle Duchêne[1], Bart Vos[1], Jordan Dieter Groh[1], Pratima Sawant[2], and Timo Betz[1] — [1]Third Institute of Physics - Biophysics, Georg August University Göttingen — [2]Institute for X-Ray Physics, Georg-August-Universität Göttingen

Oocytes form the origin of many developing organisms and display distinct mechanical responses compared to smaller somatic cells. Their nuclei are unusually deformable, mimicking whole-cell shape during external compression. Apart from chemical signaling, mechanosensing in the nucleus plays a central role in gene expression. However, the forces involved in oocyte deformation are not quantified and still poorly understood.

Here, we aim to employ microfluidic methods to investigate deformations of cells and nuclei in a well-controlled, high-throughput method via shear flow deformability cytometry, commonly referred to as real-time deformability cytometry (RT-DC). We modified this method for oocytes, by first generating a preliminary channel design using COMSOL simulations. To evaluate device performance after fabrication, polyacrylamide beads are studied and provide a reference for estimating oocyte behavior in the same geometry. Finally, oocyte deformation is recorded to obtain mechanical properties. This helps us to better understand forces involved oocyte development and migration on its journey from the ovaries to an embryo.

BP 7.33 Mon 15:00 P5

Linking Theory and Experiment: RBC Deformation in a Cross-Shaped Microfluidic Channel — •Clara Gremmelspacher[1], Stephan Gekle[1], and Manouk Abkarian[2] — [1]Universität Bayreuth — [2]Centre de Biologie Structurale, Montpellier

Red blood cells (RBCs) must deform significantly to pass through narrow capillaries, a process governed by membrane mechanics such as shear elasticity and membrane viscosity. We use a combined experimental and computational approach to study RBC stretching under extensional flow. The investigated setup consists of two opposing inflow channels and two perpendicular outflow channels arranged in a cross shaped geometry creating a stagnation point at the intersection. By comparing deformation patterns and timescales between microfluidic experiments and Bounday-Integral-Simulations, we extract key mechanical properties of the RBC membrane. This approach links theoretical descriptions to observed dynamics, providing insights into microcirculatory behavior.

BP 7.34 Mon 15:00 P5

Mechanistic Insights into PFAS Interactions with Biological Membranes — •Samuel Türken[1], Doreen Biedenweg[2], Janet Krüger[1], Stefanie Spiegler[2], Bob Fregin[2], Wibke Busch[1], and Oliver Otto[2] — [1]Helmholtz Centre for Environmental Research - UFZ, Leipzig, Germany — [2]Institute of Physics - University of Greifswald, Greifswald, Germany

Per- and polyfluoroalkyl substances (PFAS) are widely used, highly persistent organic chemicals that accumulate in humans and the environment. PFAS exposure is associated with a range of adverse health and environmental effects, yet their mechanisms of action in human cells remain poorly understood. Molecular simulation studies show that PFAS integrate into phospholipid membranes and alter membrane fluidity in a structure-dependent manner.

To investigate how PFAS influence whole-cell mechanics, we used real-time deformability cytometry (RT-DC), which provides single-cell, millisecond-scale measurements of deformation and cell elasticity, i.e., the Young's modulus. This approach captures the mechanical response of HL60 cells after 1 minute PFAS exposures, reducing the contribution of slower cellular adaptive processes. Complementing this, we quantified PFAS-induced changes in membrane order using a Laurdan-based assay. We found that PFAS exposure decreased cell deformability and increased cell stiffness, detectable even at environmentally relevant concentrations in a dose- and structure-dependent manner. Combined membrane-order and RT-DC results show that PFAS alter membrane physical state and thereby modulate whole-cell mechanics.

BP 7.35 Mon 15:00 P5

Bat thermomechanics of red and white blood cells as a blueprint for human hibernation — •Bob Fregin[1,2], Doreen Biedenweg[1], Gerald Kerth[3], and Oliver Otto[1,2] — [1]Institute of Physics, University of Greifswald, Greifswald, Germany — [2]German Center for Cardiovascular Research, Greifswald, Germany — [3]Applied Zoology and Nature Conservation, Zoological Institute and Museum, University of Greifswald, Greifswald, Germany

Hibernation lets mammals conserve energy by sharply slowing metabolism during cold or resource-poor periods. A key challenge is sustaining blood flow at low body temperatures ($\leq$ 10 °C). Here, the mechanical properties of red (RBCs) and white blood cells (WBCs) could play a crucial role, which we studied for the hibernating common noctule bat, the non-hibernating Egyptian fruit bat, and humans. Using dynamic real-time deformability cytometry, RBC and WBC elasticity and viscosity were measured at physiologically-relevant time scales (Milliseconds) and temperatures (37 °C, 23 °C, and 10 °C).

Our analysis revealed a temperature-driven increase in RBC elasticity and viscosity, which is mainly influenced by membrane properties and not the cytosol. This effect is significantly enhanced in bats. Finally, our data demonstrate that RBC membranes of both bat species display a transition to a viscous-like state at lower temperatures, which is not explained by seasonal variations of environmental factors but seems to originate from physical properties of the cell membrane. Our results suggest blood cell thermomechanics as a target for future research on human hibernation.

BP 7.36 Mon 15:00 P5

Enhancing optical parameters of platelets in real-time deformability cytometry — •Tristan Franke, Bob Fregin, Doreen Biedenweg, Lucia Wegbünder, and Oliver Otto — Institute of Physics, University of Greifswald, Greifswald, Germany

Real-time deformability cytometry (RT-DC) is a high-speed, label-free cytometric method for imaging and analyzing cell mechanical properties. Cells are flushed through a narrow microfluidic channel and deform by hydrodynamic stresses, while being illuminated by a stroboscopic high-power LED and imaged by a high-speed CMOS camera.

Using RT-DC allows for investigating platelet mechanics, which are key to blood coagulation and may help explain underlying causes of, e.g., coagulopathy and thrombosis. However, with a cell size of only a few micrometers, platelets appear to be difficult to analyze optically, resulting in low image quality, often characterized by motion blurring, low brightness, and a low level of morphological detail.

We investigated the interplay between various parameters, including LED exposure time (brightness), hydrodynamic flow rate, objective magnification, numerical aperture, and camera settings, to identify optimal imaging parameters. To further enhance image quality, we inserted a 2.18x intermediate lens in our inverted microscope setup to increase image magnification, previously not possible to achieve, while preserving the depth of focus. In combination with an extended exposure time of 9.3 μs, and a 2x digital gain our results demonstrate a balance between image brightness and motion blurring while achieving improved contrast and resolution in RT-DC.

BP 7.37 Mon 15:00 P5

Microparticle traction force microscopy for DNA microparticles based on experimental and computational advances — •Bastian K. Kraus[1,2], Simon Brauburger[1,2], Tobias Walther[3], Tobias Abele[3], Kerstin Göpfrich[3], and Ulrich S. Schwarz[1,2] — [1]Institute for Theoretical Physics (ITP), Heidelberg University — [2]BioQuant, Heidelberg University — [3]Center for Molecular Biology (ZMBH), Heidelberg University

Traction force microscopy quantifies cellular forces by inferring traction fields from the displacements of fiducial markers embedded in soft elastic substrates. Microparticle traction force microscopy extends this concept by employing elastic spherical microparticles as finite-sized force sensors. Traction fields can be recovered by two methods: the volume method, which tracks nanoparticles inside the microparticle, and the surface method, which only considers the deformed microparticle surface. Here, the two approaches are compared systematically, each as a pipeline combining image processing and elasticity theory. Moreover, they are both implemented in the same experimental system, using soft DNA microparticles with different fluorescent labels, which are held and deformed in micropatterned wells. We find that the two methods can lead to similar results, but have different advantages. While the volume method requires fewer assumptions in the elasticity

equations, the surface method is less sensitive to imaging artifacts.

BP 7.38 Mon 15:00 P5

A fast & quantitative method to study membrane elasticity of suspended cells — •Eric Sündermann, Bob Fregin, Doreen Biedenweg, Jan Wilder, Stefanie Spiegler, and Oliver Otto — Institute of Physics, University of Greifswald, Greifswald, Germany

Current research acknowledges the importance of bulk and membrane mechanics for understanding cell state and function under pathophysiological conditions. While microfluidic technologies allow for measuring bulk mechanical properties at rates exceeding 1,000 cells per second, traditional approaches for assessing membrane elasticity lack the throughput required to screen entire cell populations.
Here, we utilise membrane tension cytometry (MTC), a microfluidic method combining shear-induced deformation of cells with the capabilities of Flipper-TR, a fluorophore with fluorescence lifetime proportional to the cell membrane elasticity. We established a calibration procedure using thousands of osmotically stressed red blood cells, and confirmed a quantitative relation between surface area and membrane elasticity introduced earlier for different cell models. Next, we focused on HL60 cells, a myeloid precursor cell line. We disturbed cholesterol and filamentous actin, and demonstrated that MTC is sensitive to changes in lipid composition, while being insensitive to cytoskeletal alterations. Finally, we directly measured the mitochondrial membrane elasticity inside living cells using Mito Flipper-TR. Interestingly, mitochondria seem to respond to an external hydrodynamic stress by an increase in membrane elasticity, which might be relevant to understand fission and fusion processes from a mechanical perspective.

BP 7.39 Mon 15:00 P5

The nature of correlations in the fractional Kelvin-Voigt model — •Dorian Marx[1], Raffaele Mendozza[2], Till Moritz Münker[1], Peter Sollich[2], and Timo Betz[1] — [1]Third Institute of Physics - Biophysics, Georg-August-University Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany — [2]Institute for Theoretical Physics, Georg-August-University Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

The inside of cells is a complex, non-equilibrium system. We are interested in the mechanics of this intracellular space, which typically are phenomenologically well described by a complex double-power law (fractional Kelvin-Voigt model). There have been multiple studies on intra- and extracellular systems using different measurement methods that indicated a correlation in the model parameters. We present an analytical and numerical analysis of the complex double-power law model, uncovering the nature of such a correlation and its dependency on measured frequency range. This results in a tool to judge experimental findings and to discern significant, possibly meaningful correlations from those stemming from the nature of the model. As complex double-power law models (or a subclass of them) seem to continue being used in the study of intracellular mechanics, we expect this theoretical investigation to be relevant going forward.

BP 7.40 Mon 15:00 P5

The biophysical response of HL60 cells to a millisecond osmotic stress — •Lucia Wegbünder[1], Eric Sündermann[1], Lea Graichen[1], Doreen Biedenweg[1], Marta Urbanska[2], and Oliver Otto[1] — [1]Institute of Physics, University of Greifswald, Greifswald, Germany — [2]Department of Physiology, Development and Neuroscience, University of Cambridge, Cambridge, United Kingdom

Local differences in the concentration of osmolytes within the human body require cells to consistently regulate their water in- and efflux. While cells are known to change their volume and mechanical properties on the timescale of seconds to minutes, their millisecond response to an osmotic stress has been, so far, unexplored.

Here, we leverage real-time deformability cytometry to apply osmotic challenges to cells and measure their physical properties including size and elastic modulus 0.5 to 10 milliseconds after exposure. We focus on HL60 cells (a myeloid precursor cell line), which are flushed through a microfluidic channel and in which they are in contact with a sheath fluid of varying osmolality. Similar to longer timescale regimes, we observe swelling under hypoosmotic, and shrinkage under hyperosmotic conditions. Independent of stress direction there is a decrease in the Young's modulus of cells. This is in contrast with long timescale findings, where cells are consistently reported to increase their stiffness under hypertonicity. The ability of cells to physically respond to osmotic stress within milliseconds can be of physiological consequences in situations where cells are exposed to steep osmotic gradients, as is the case for immune cells migrating through changing environments.

BP 7.41 Mon 15:00 P5

Mechanical and Viscoelastic Characterisation of *Giardia duodenalis* Trophozoites Using SCFS and nDMA — •Johannes Mischo[1,2], Maike Derenek[1], Markus Bischoff[1], Karin Jacobs[2], Chistian Klotz[3], Anton Aebischer[3], and Philipp Jung[1] — [1]Institute of Medical Microbiology and Hygiene, Saarland University, Homburg, Germany — [2]Experimental Physics, Saarland University, Saarbrücken, Germany — [3]Department of Infectious Diseases, Unit 16, Robert Koch-Institute, Berlin, Germany

Giardia duodenalis trophozoites use a ligand-independent, mechanically dominated suction or clutching mechanism mediated by the ventral disc to resist intestinal shear [1]. Little is known about the mechanical and viscoelastic properties of the cell. We used single-cell force spectroscopy (SCFS) on individual trophozoites to record detachment force-distance profiles. These datasets provide mechanical information of whole-cell deformation during pull-off, including contributions from the cell body, ventral disc and ventrolateral flange. Complementarily, we measured cell-body elasticity by nano-dynamic mechanical analysis (nDMA). Ventral disc and flange are inaccessible to nDMA because stationary cells keep them in surface contact. We observed single-digit kPa storage and loss moduli with a negative correlation between stiffness and approach speed. Together, SCFS and nDMA provide complementary mechanical information and a framework for understanding how *Giardia* balances elasticity and structural rigidity during its adhesion cycle and survival in the small intestine.

[1] Gunaratnam et al. Nanoscale, 2024, 16 (14), 7145-7153.

BP 7.42 Mon 15:00 P5

Dynamics of confined immune cell migration — •Santiago Kuhl and Joachim Rädler — Ludwig-Maximilians-Universität, München, Germany

Immune cells must invade tissue to reach their targets, but the dynamics and mechanics of their invasiveness are not well understood at the single cell level. Photolithographically fabricated 3D hydrogel micro-structures provide a promising platform for probing cellular invasiveness. Here we use nonadhesive 3D dumbbell-microcavities to enforce repeated encounters between single cells and pores of varying dimensions, simulating migration in a dense extracellular matrix. This platform enables us to record trajectories of macrophages and dendritic cells and measure dwell times and transmigration probabilities as a function of confinement.

BP 7.43 Mon 15:00 P5

Structural changes of sarcomeres in iPSC-derived 3D engineered skeletal muscle after laser-induced injury — •Lisa-Marie Scharfenstein[1,2], Daniel Härtter[1], Mahboubeh Farajian[2], Mattias Luber[2], Timo Betz[2], Wolfram Zimmermann[1], and Arne Hofemeier[1] — [1]Department of Pharmacology and Toxicology, University Medical Center Göttingen, Göttingen, Germany — [2]Third Institute of Physics, University of Göttingen, Göttingen, Germany

Skeletal muscle injury models are employed to study mechanisms of muscle repair and regeneration. Commonly used muscle injury models such as cryo-injury, crush-injury and cardiotoxin-treatment do not allow for precisely localized muscle damage. Here, we introduce precise laser-based injury in human iPSC-derived 3D engineered skeletal muscle (ESM) tissue grown in a custom-made culture platform. Using high-resolution live microscopy and a sarcomere reporter model (ACTN2-Citrine), we monitor Z-band morphology on timescales of seconds to several days using the previously by our group introduced AI-based Sarcomere Analysis Multi-tool (SarcAsM). In doing so, we find an average sarcomere elongation of (0.45 +- 0.061) mum (mean +- sem) within 50 mum distance from the injury, that further decays exponentially from the location of injury towards the periphery, suggesting local impaired tensional homeostasis in myofibers surrounding the injury. Taken together, we report first data obtained in a novel human iPSC-based skeletal muscle injury model, which we intend to use for repair and regeneration inducing drugs.

BP 7.44 Mon 15:00 P5

What we learned from 6000 patient blood samples measured with deformability cytometry: age, biomarkers, and disease mechanotypes — •Markéta Kubánková[1,2], Lena Summa[1,2], Maximilian Schlögel[1,2], Martin Kräter[1,2], Manfred Rauh[3], Markus Metzler[3], and Jochen Guck[1,2] — [1]Max Planck Institute

for the Science of Light, Erlangen, Germany — [2]Max-Planck-Zentrum für Physik und Medizin, Erlangen, Germany — [3]Department of Pediatric and Adolescent Medicine,University Hospital Erlangen, Germany

Deformability cytometry is a label-free microfluidic imaging technique that quantifies mechanical and morphological properties of single cells at ~1000 cells/s directly from brightfield images. Here we analyse >6000 whole-blood measurements from a clinical cohort ranging from newborns to adults. We developed an automated analysis pipeline combining feature extraction with clustering and classification of the main blood cell populations, replacing manual gating. Using this framework, we established age-dependent baselines of size and deformation for the major cell classes. We correlated the features with routine biomarkers such as CRP, IL-6 and PCT. Specific mechanotypes, particularly of neutrophils and monocytes, showed associations with these markers and provided information beyond simple cell counts. We also quantified the impact of pre-analytical confounders, such as the time between blood draw and measurement. Finally, by stratifying samples according to clinical information, we identified disease-related patterns in cell mechanotypes, providing a biophysical basis for future diagnostic applications.

BP 7.45 Mon 15:00 P5

Investigating the role of the membrane-associated cytoskeleton in neuronal action potential propagation — •Julia Butzke[1] and Kristian Franze[1,2,3] — [1]Chair of Neuronal Mechanics, Medical Institute of Biophysics, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany — [2]Max-Planck-Zentrum für Physik und Medizin, Erlangen, Germany — [3]Department of Physiology, Development and Neuroscience, University of Cambridge, Cambridge, UK

During maturation, neuronal axons develop submembraneous F-actin rings as a part of the membrane-associated periodic skeleton (MPS). The MPS has been shown to regulate axon diameter, provide mechanical support and contribute to axonal transport. However, the role of the MPS in successful action potential propagation in single axons is not yet fully understood. In this project, we investigate the impact of submembraneous F-actin rings on the mechanical aspects of action potentials. Using super-resolution microscopy, we study the effect of different F-actin-disrupting drugs on the presence and periodicity of F-actin rings in primary hippocampal mouse neurons. We then use atomic force microscopy to measure the mechanical waves that accompany action potentials in axons with different levels of F-actin ring periodicity. By analysing the possible correlation between F-actin ring periodicity and the propagation properties of the mechanical waves, we will contribute to a better understanding of the mechanical aspects of neuronal signal transmission.

BP 7.46 Mon 15:00 P5

Characterizing the Effective Membrane Tension Response to Substrate Stiffness Using AFM and Optical Tweezers — •Tina Borić[1,2], Maria Villamarin[1,2], Julia Butzke[1,2], Eva Kreysing[4], and Kristian Franze[1,2,3] — [1]Max-Planck-Zentrum für Physik und Medizin, Erlangen, Germany — [2]Friedrich-Alexander-Universität, Erlangen-Nürnberg, Erlangen, Germany — [3]Department of Physiology, Development and Neuroscience, University of Cambridge, Cambridge, UK — [4]University of Warwick, Coventry, UK

Cellular membranes change their physical properties in response to mechanical stimuli, such as changes in tissue stiffness. Membrane tension transduces these mechanical signals into intracellular responses via mechanosensitive ion channels. However, how and if a change in tissue stiffness affects the surface mechanics of the cell, which in turn would contribute to the activation of mechanosensitive ion channels, is not yet known. To investigate the dependence of the effective membrane tension on substrate stiffness, we culture HEK293T cells and hippocampal neurons on custom made compliant substrates, and measure tether forces using optical tweezers and AFM. Furthermore, we use pharmacological treatments that primarily affect the actin cortex and membrane composition to characterize their contributions to the effective membrane tension. Ultimately, our aim is to understand how stiffness induced changes in membrane tension lead to the activation of the mechanosensitive ion channel Piezo1. Our work will contribute to the understanding of how mechanosensitive ion channels are gated, which may have important implications for drug design in the future.

BP 7.47 Mon 15:00 P5

Topologically invariant coordinates for dynamic epithelia undergoing morphogenesis — •Paweł Korzeb[1], Marko Popović[1,4], and Frank Jülicher[1,2,3] — [1]Max Planck Institute for Physics of Complex Systems, Dresden, Germany — [2]Center for Systems Biology, Dresden, Germany — [3]Cluster of Excellence Physics of life, Technische Universität Dresden, Dresden, Germany — [4]Rudjer Bošković Institute, Zagreb, Croatia

Epithelia are two-dimensional tissues, sheets of tightly connected cells that form many structures in organs. Such tissues acquire their shape and function through morphogenesis, a process that involves changes in both their geometry and cellular network topology. A key question in morphogenesis is to understand how cellular processes, such as cell division or T1 transitions, contribute to tissue morphology by changing its geometry and topology. For a curved epithelium, this problem can be formulated in a continuous covariant description on the tissue surface. In this work, we propose two sets of topologically invariant coordinates, describing cellular networks, obtained by embedding a graph representation of the network into $\mathbb{R}^2$ using only its connectivity, without the need to take into account the underlying tissue geometry. We construct these embeddings using the spectrum of the graph Laplacian and a spring-meshwork representation. Local changes of these topologically invariant coordinates allow us to identify the cellular processes occurring during tissue development. This formalism provides a framework to investigate the coupled evolution of epithelial geometry and topology.

BP 7.48 Mon 15:00 P5

BeadBuddy: Multiscale shape analysis of in-vivo stress sensors for force inference — •Alejandro Jurado Jiménez[1], Jonas Isensee[3], Arne Hofemeier[2], Lea Johanna Krüger[4], Raphael Wittkowski[5], Ramin Golestanian[3], Philip Bittihn[3], and Timo Betz[1] — [1]Third Institute of Physics-Biophysics, University of Göttingen — [2]Institute of Pharmacology and Toxicology, University Medical Center Göttingen — [3]Max-Planck-Institute for Dynamics and Self-Organization, Göttingen — [4]Institute of Theoretical Physics, University of Münster — [5]Department of Physics, RWTH Aachen University, DWI - Leibniz Institute for Interactive Materials

The measurement of stresses and forces at the tissue level has proven to be an indispensable tool for the understanding of complex biological phenomena such as cancer invasion, embryo development, or wound healing. One of the most versatile tools for force inference at the cell and tissue level are elastic force sensors, whose biocompatibility and tunable material properties make them suitable for many different experimental scenarios. The evaluation of those forces, however, is still a bottleneck due to the numerical methods seen in the literature until now, which are usually slow and render low experimental yield. Here, we present BeadBuddy, a ready-to-use platform for the evaluation of deformation and stresses from fluorescently labeled sensors within seconds. The strengths of BeadBuddy lie in the precomputed analytical solutions of the elastic problem, the abstraction of data into spherical harmonics, and a simple user interface that creates a smooth workflow for force inference.

BP 7.49 Mon 15:00 P5

Mechanics of reconstituted cardiac microtissues — •Polina Malova, Mattias Luber, Noemie Veyret, Anna Mukhina, Till Münker, and Timo Betz — Georg-August Universität Göttingen

Cardiovascular diseases remain the leading cause of mortality in Western countries [1]. Heart failure, which characterized by reduced cardiac output, myocardial thickening, and diminished contractile strength is among them and is highly prevalent. Human induced pluripotent stem cells (hiPSCs) are widely used for cardiac disease modelling and drug screening due to a preservation of patient-specific genetic backgrounds [2]. hiPSC-derived engineered human myocardium (EHM) microtissues provide an opportunity for *in vitro* research of the cardiac environment in a three-dimensional (3-D) system. Despite extensive characterization of the heart as a complex 3-D system, the mechanics of cellular interactions within the cardiac tissue still require detailed clarification. This work examines how cells within EHM microtissues mechanically interact with neighbouring cells and the extracellular environment to generate observed load curves. We compare contraction profiles of tissues composed of cardiomyocytes with cardiac fibroblasts to those containing cardiomyocytes with human foreskin fibroblasts. In addition, we investigate the contribution of extracellular matrix homeostatic tension to the mechanics of the 3-D system. These findings support the further development of 3-D tissue models for patient-specific drug screening.

[1] World Health Organization, 2022
[2] Takahashi K, Yamanaka S., 2006

BP 7.50 Mon 15:00 P5

Connecting tissue stiffness and glycosylation patterns in the developing brain — •Sarah Fritsche[1,2], Sebastián Vásquez-Sepúlveda[1,2], Leonhard Möckl[3,4], and Kristian Franze[1,2,5] — [1]Medical Institute of Biophysics, FAU Erlangen-Nuremberg, Germany — [2]MPZPM, Erlangen, Germany — [3]Department of Medicine 1/CITABLE, University Hospital Erlangen, FAU Erlangen-Nuremberg, Germany — [4]MPL, Erlangen, Germany — [5]Department of Physiology, Development and Neuroscience, University of Cambridge, United Kingdom

Mild malformation of cortical development with oligodendroglial hyperplasia and epilepsy (MOGHE) is a pathological entity leading to drug resistant epilepsy that is characterised by increased density of oligodendroglial cells, hypomyelination, and heterotopic neurons in the white matter. This malformation has been linked to mutations of the galactose transporter SLC35A2. At the same time, processes like brain folding involve motion and must therefore be driven by large scale forces. This is why, in order to comprehend this disease to a greater extent, we are investigating the connection between the physical properties of brain tissue and its glycosylation patterns to emulate brain malformations in the Xenopus laevis embryo. The physical properties are measured via atomic force microscopy and the glycosylation patterns via super-resolution microscopy of metabolically labelled galactose, as well as antibody- and lectin stainings. With this approach we aim to understand the relation between the mechanical properties of brain tissue and developmental pathologies.

BP 7.51 Mon 15:00 P5

Cellular shape anisotropy couples to morphogen transport to drive pattern formation — •Stefan Nienhaus[1] and Diana Khoromskaia[1,2] — [1]Institut für Theoretische Physik, Universität Münster, 48149 Münster, Germany — [2]Center for Soft Nanoscience, Universität Münster, 48149 Münster, Germany

To attain their intended structures, many tissues have been shown to rely on morphogens that induce concentration-dependent changes in cell fate and in cellular mechanical properties. These changes can alter the transport properties of the morphogen within the affected tissue. Hence, a feedback loop may arise in which tissue patterning influences morphogen distribution, which in turn influences tissue patterning (bioRxiv:658228). This concept also applies to tissues with nematic order, which has been shown to be crucial to certain morphogenetic processes that predominantly occur at topological defects.

In this work, we explore the complex couplings between morphogens and nematics and aim to investigate the role of topological defects in localising cellular signalling for morphogenesis. Previous work has shown that cellular shape anisotropy may lead to anisotropic diffusion (bioRxiv:683494). Here, through numerical simulations of a reaction-diffusion system coupled to a nematic order parameter, we study how locally anisotropic diffusion affects the observed patterns. Introducing a concentration-dependent nematic alignment as a next step, we will investigate mechanisms of self-organisation that arise from this inherent coupling of morphogens and nematic order in tissues.

BP 7.52 Mon 15:00 P5

Quantifying vascular morphology on a chip — •Leonie Karr — TUM, Munich, Germany

Our human vasculature is dynamic, growing and reorganising not only in development but also continuously adapting its morphology. Yet, what determines vessel formation and branching in healthy and disease states seems complex, given the multitude of contributing factors. Our focus lies in growing a human vasculature within the controlled environment of a chip, with the goal of quantifying the flow properties of self-organised in vitro networks. Employing image analysis techniques in conjunction with flow simulation methods, our objective is to accurately quantify how flow and related properties, such as shear stress and absorption determine network architecture. The results obtained from our analyses will significantly contribute to the development of next-generation therapeutics aimed at targeting vessel development.

BP 7.53 Mon 15:00 P5

Mechanics of spinal cord regeneration in Xenopus laevis — •Maria Tarczewska[1,2] and Kristian Franze[1,2,3] — [1]Max-Planck-Zentrum für Physik und Medizin, Erlangen, Germany — [2]Medical Institute of Biophysics, Friedrich-Alexander- Universität Erlangen-Nürnberg, Erlangen, Germany. — [3]Department of Physiology, Development and Neuroscience, University of Cambridge, Cambridge, UK

In mammals, spinal cord injury (SCI) often leads to paralysis due to the limited regeneration of damaged neurons in the central nervous system (CNS). The African clawed frog (Xenopus laevis) can regenerate CNS neurons during its early life stages - pre-metamorphosis. However, this ability is lost post-metamorphosis, in frogs adult form. Biochemical differences between pre- and post-metamorphosis frog spinal cord tissue identified so far cannot fully explain the differences in their regenerative capacity, suggesting that other signals may contribute to the regeneration. Following SCI, the composition of the extracellular matrix changes, and scar tissue forms. In mammals, this scar tissue, which is softer than healthy tissue, inhibits axon regeneration. In zebrafish, whose CNS neurons regenerate after SCI, tissue stiffens after injury. Mechanical properties of frog spinal cord tissue have not been measured yet. Because mechanosensing of tissue stiffness is critical for axon growth, we test the hypothesis that tissue stiffness is a critical factor in axon regeneration after SCI. We investigate the mechanical differences in the SCI lesion environment in Xenopus. By examining both tissue stiffness and molecular changes, we will illuminate the relationship between these factors and the regenerative capabilities.

BP 7.54 Mon 15:00 P5

Dimensionality and confinement reshape competition in cellular renewing active matter — •Patrick Zimmer[1,2], Philip Bittihn[1,2], and Yoav G. Pollack[1,2] — [1]MPI for Dynamics and Self-Organization, Göttingen, Germany — [2]Institute for the Dynamics of Complex Systems, Göttingen University, Germany

Cellular renewing active matter—assemblies of proliferating and apoptotic cells—underlies tissue homeostasis, morphogenesis, and clonal competition. Previous work in one-dimensional periodic systems identified a fitness advantage associated with rapid dead-cell clearance, an "opportunistic" competition mechanism. Extending this framework, we study two-dimensional cellular aggregates and show that dimensionality modifies the interplay between competition mechanisms for clones with different clearance rates: in 2D, opportunistic and homeostatic-pressure-based competition jointly shape clonal selection. We introduce an explicit circular confinement to probe how boundaries modulate this interplay. While opportunistic competition persists, distinct timescale-dependent behaviors emerge through weakened homeostatic-pressure-based competition near boundaries. Structural analysis reveals that confinement promotes tangential alignment and spatially heterogeneous homeostatic pressure, thereby reshaping competitive outcomes at tissue edges. Our study connects newly discovered competition mechanisms with more realistic biological contexts, highlighting how dimensionality and spatial constraints influence tissue structures and modulate competition in heterogeneous cell populations, with implications for tumor growth dynamics and tissue development.

BP 7.55 Mon 15:00 P5

Remotely Actuated Elastic Meta-Lattices using Bjerknes Forces — •Laurin Sartori[1], Peer Fischer[1,2], and Athanasios G. Athanassiadis[1,2] — [1]Heidelberg University, Heidelberg, Germany — [2]Max-Planck Institute for Medical Research, Heidelberg, Germany

Acoustically-responsive elastic structures have recently gained interest as tools for gentle, wireless manipulation of biological materials. By combining acoustic effects with elastic structures, they can be actuated dynamically to even manipulate single cells in fluidic chambers. However, there is currently a large gap between existing manipulators designed for single cells and larger-scale acoustically-actuatable materials that could be integrated with larger biological tissues or organoids.

Here, we introduce a dynamic acoustic metamaterial that can be change both its geometric configuration and elastic properties in response to sound. The metamaterial consists of an elastic lattice with embedded gas bubbles, and is actuated leveraging the secondary radiation forces between embedded bubbles. By tuning the driving or the microscopic structures the specific response of the material can be tailored. We introduce a numerical model to predict the response of arbitrary lattices, and validate the model experimentally using carefully designed structures that achieve the desired motion.

The engineered lattices shown in this work can be used as building blocks for metamaterials with a remotely tunable stiffness, auxetic properties and memory behavior, providing new interaction paradigms for applications in bio-interfaced soft robotics.

BP 7.56 Mon 15:00 P5

Direct Measurement and Enhancement of Piezoelectric Fields around Microparticles in an Ultrasound Field — •Mareike Stoll[1,2], Honorata Kazimierczak[1,2], Peer

Fischer[1,2], and Athanasios Athanassiadis[1,2] — [1]Institute for Molecular Systems Engineering and Advanced Materials, Heidelberg University, Heidelberg, Germany — [2]Max Planck Institute for Medical Research, Heidelberg, Germany

There is growing interest in designing ultrasound-responsive materials that broaden the possibilities for non-invasive, remotely controlled therapies. In this context, piezoelectric micro- and nanoparticles are emerging as promising mediators, generating electric fields and reactive chemical species that can interact with biological tissues. Despite growing evidence suggesting macroscopic effects, a direct measurement of the piezoelectric response of individual particles under an applied ultrasound field has not yet been demonstrated. This knowledge gap presents a hurdle to further design and targeting of piezoelectric particle-mediated therapies. In this work, we introduce a new methodology and provide the first direct measurements of electric potential generated by piezoelectric microparticles during ultrasonication. By mapping the time-varying potential around microparticles we are able to quantify the ultrasound-induced fields and identify enhancement strategies. These results provide a first step to disentangling the contributions of different physical processes involved in sonopiezoelectric therapies, and provide insights into the feasibility and design strategies for therapies based on ultrasound-activated piezoelectric materials.