

Biophysics and Soft Matter

Friday, 22.08.2025, Room HS 30

Time	ID	BIOPHYSICS AND SOFT MATTER I: BIOPHYSICS <i>Chair: Christof Fattinger</i>
11:00	901	<p style="text-align: center;">A generic mechanism for force-modulated adsorption of E. coli</p> <p style="text-align: center;"><i>Erik Reimhult², Anders Lundgren¹, Peter D. J. van Oostrum², Jagoba Iturri³, Michael Malkoch¹, José Luis Toca-Herrera³,</i></p> <p style="text-align: center;"><i>¹ Department of Chemistry and Molecular Biology, University of Gothenburg</i> <i>² Institute of Colloid and Biointerface Science, BOKU University</i> <i>³ Institute of Biophysics, BOKU University</i></p> <p>Many bacteria interact with surfaces via long (μm) and thin (nm) tethers called fimbriae or pili. A particularly intriguing function of pili is how they aid, e.g., E. coli, in attaching more strongly to surfaces in flow than in the absence of flow and performing stick-slip and roll motions along the surface. This has been attributed to molecular so-called catch-bonds between host cell-surface sugars and lectins at the pilus' tips.</p> <p>We used nanopatterned substrates, in situ microscopy, in-line holography, and atomic force microscopy to demonstrate that a molecular mechanism is unnecessary to explain the adsorption and motion of fimbriated E. coli. The loss of translational motion in high shear is caused by a shear force-induced push of the bacteria toward the interface. Pushing the bacteria closer to the surface increases the binding valency, as shorter fimbriae can bind to the surface. In contrast to catch-bond force-controlled binding mechanisms, force modulation of the binding valency is generic, applying to any surface and likely to other microorganisms.</p>
11:30	902	<p style="text-align: center;">Understanding Fracture in Physically Crosslinked Hydrogels</p> <p style="text-align: center;"><i>Kerstin G. Blank^{1,2}, Alberto Sanz de León², Geonho Song^{1,2}, Isabell Tunn², Tanja D. Singewald¹</i> <i>¹ Johannes Kepler University Linz, Austria,</i> <i>² Max Planck Institute of Colloids and Interfaces, Potsdam, Germany</i></p> <p>Hydrogels for cell culture are typically designed with controlled linear viscoelasticity. As cells exert tensile and compressive forces, non-linear mechanical properties are, however, equally important. We use a bottom-up approach to synthesize physically crosslinked hydrogels from molecularly defined building blocks. A library of coiled coil crosslinks with tunable molecular properties enables a systematic exploration of their influence on hydrogel stress relaxation and fracture. Rheological measurements reveal that stress relaxation is determined by the equilibrium thermodynamic and kinetic properties of the crosslinks. In contrast, fracture is governed by their dynamic mechanical stabilities, as quantified with single-molecule force spectroscopy. Crosslinks with identical thermodynamic but different molecular mechanical stabilities yield hydrogels with similar linear viscoelastic properties but controlled and distinct yield stresses.</p>
11:45	903	<p style="text-align: center;">Effect of 2D confinement and substrate properties on bacterial self-organization at surfaces</p> <p style="text-align: center;"><i>Vincent Hickl, Antonia Neels, René Rossi, Katharina Maniura, Bruno Silva</i> <i>Empa, St. Gallen, Switzerland</i></p> <p>Surface-attached bacterial colonies exhibit collective behaviors that play an important role in the spread of microbial infections. Many open questions remain about how the bacteria's self-organization adapts to the variety of different environments they encounter in natural settings. Here, the effects of dimensional confinement and material properties on the collective behaviors of pathogenic bacteria are described. Biofilm-forming bacteria are grown confined to a single monolayer between different substrates. Using single-cell segmentation and tracking, the orientational ordering in the colony, cell morphologies, and swimming behaviors are shown to be altered by 2D confinement. These results demonstrate the remarkable breadth of collective behaviors exhibited by bacteria in different environments, which must be considered to better understand bacterial colonization of surfaces.</p>

12:00	904	<p style="text-align: center;">Synthesis and flow behaviour of polymer-grafted nanopores</p> <p style="text-align: center;"><i>Giacomo Chizzola, Mudassar Virk, Peter D. J. van Oostrum, Erik Reimhult</i> <i>Institute of Colloid and Biointerface Sciences, BOKU University, Vienna, Austria</i></p> <p>Nanopores in solid substrates have received great interest for many years, often inspired by their similarity to important biological systems. So far, diffusion through solid-state nanopores grafted with polymer brushes has been investigated; however, transport by diffusion is severely restricted, especially as the pore dimensions approach the size of the diffusing molecules. In many applications and biological systems, flow and transient flow might play an important role, as transport through a nanopore is only efficient if the flow is convective.</p> <p>In polymer-grafted nanopores, the flow profile might strongly deviate from the Poiseuille flow profile. The polymer can also deform under flow and affect it transiently. We set out to achieve controlled and reproducible growth of polymers grafted from the inner surface of nanopores and characterize the dynamic flow circuit behavior for future applications, such as gated protein and other biomolecular transport.</p>
12:15	905	<p style="text-align: center;">Electro-Acoustic Spinning for the Characterization of Individual Cells</p> <p style="text-align: center;"><i>Tayebeh Saghaei, Erik Reimhult, Peter D. J. van Oostrum</i> <i>Institute of Colloid and Biointerface Science, BOKU University, Vienna, Austria</i></p> <p>We have developed electro-acoustic spinning (EAS), a label-free method capable of concurrently assessing individual cells' electrical and mechanical characteristics. Deformable suspended objects rotate when subjected to a combined electric and acoustic field. The frequency-dependent rotation spectrum depends on the mechanical and electrical properties of the object and its surroundings. Therefore, EAS enables the characterization of a broad range of "soft" colloids based on their electrical and mechanical properties. In the same experimental setup, we found that the rotation speed and direction depend sensitively on the type of object, the presence of ionic surfactants, pH, and ionic strength. The rotational behavior is consistent throughout the microscope's field of view, allowing for parallelized, high-throughput characterization. We demonstrated EAS's capability to distinguish cells with subtle differences in electrical and mechanical properties, including variations in age or passage number.</p>
12:30	Poster Awards and Closing Ceremony	
12:45	Lunch	
	<p>BIOPHYSICS AND SOFT MATTER II: LIGHT AND BIOPHYSICS <i>Chair: Rainer Leitgeb, Med. Universität Wien</i></p>	
14:00	911	<p style="text-align: center;">New contrasts for holographic microscopy for novel applications in biotechnology and environmental monitoring</p> <p style="text-align: center;"><i>Peter D. J. van Oostrum, Erik Reimhult</i> <i>Institute of Colloid and Biointerface Science, BOKU University, Vienna, Austria</i></p> <p>In holographic microscopy, monochromatic light is shone through a medium in which particles or microorganisms scatter some of it. The scattered light interferes with a coherent reference beam, forming holograms. In in-line holography, the ballistic part of the illumination serves as the reference beam, which guarantees perfect alignment. Holograms can be analysed either by fitting a scattering model or by back-propagation.</p> <p>We propose a simple criterion based on the phase of the scattered field that allows suppressing many artefacts and effectively enhances the resolution by a factor of two. In addition, we propose a family of interference contrasts that boost the signal-to-noise ratio further. These improvements allow for the swift locating and characterizing of thousands of individual particles, including microorganisms such as bacteria, in large volumes of liquid. We will show examples of its application to a host of real-world microscopy monitoring challenges.</p>

14:15	912	<p style="text-align: center;">Investigation of dynamic tissue properties using optical coherence tomography</p> <p style="text-align: center;"><i>Bernhard Baumann¹, Lucas May², Conrad Merkle², Sybren Worm², Gerhard Garhöfer², Ireneusz Grulkowski³</i></p> <p style="text-align: center;">¹ Medical University of Innsbruck, Austria, ² Medical University of Vienna, Austria, ³ Nicolaus Copernicus University, Torun, Poland</p> <p>The biomechanical characteristics of biological tissues often strongly depend on their microstructural composition. Pathological changes can alter these tissue properties, thus the measurement of biomechanical parameters may provide access to diagnostic information. Optical methods enable non-invasive probing of tissues as well as high-resolution imaging. Here we present optical coherence tomography (OCT) for the measurement of nano-scale tissue deformations in parallel with high-speed volumetric imaging of tissue morphology in the eye. Different methodological approaches for OCT elastography will be discussed and substantiated with in-vitro and in-vivo applications to showcase the diagnostic potential of this technology.</p>
14:30	913	<p style="text-align: center;">Light scattering angular dependency in brain tissues determined by wide-field polarimetric and time-of-flight measurements.</p> <p style="text-align: center;"><i>André Stefanov, Vladislav Stefanov, Bhanu Singh, University of Bern, Switzerland</i></p> <p>We present wide-field measurements of the backscattered light from brain tissue samples. The light is analyzed either in a polarimetric setup or in a time-of-flight one using a time-resolved single-photon camera.</p> <p>We relate the anisotropic scattering to the microscopic properties of the tissues, in particular, we can distinguish the disordered gray matter from the oriented fiber-like white matter. From the polarimetric measurements, we can determine a local average orientation in the white matter. From time-of-flight measurements, we obtain the angle-resolved scattering coefficients of white and gray matter in the brain.</p>
14:45	914	<p style="text-align: center;">How do Graphium butterflies manipulate colors by using protein?</p> <p style="text-align: center;"><i>Limin Wang, Kiyesola Rantioluwa Kolawole, Primoz Pirih, Bodo Wilts</i> <i>Department of Chemistry and Physics of Materials, University of Salzburg, Austria</i></p> <p>Colors play an essential role in the survival of organisms in many aspects, e.g., for sending signals and facilitating communication, or camouflaging. Animals use a plethora of manipulation ways to create different hues using structural and/or pigmentary colors. Here, we investigated Graphium butterflies. A special focus is on <i>G. weiskei</i> which features three different colors on their wings that are (uniquely) induced by pigmentary colors. By characterizing UV-vis spectra and Raman spectra on the butterfly wings and extractions of the pigment, we realize that this butterfly can use the same bile pigment to form three distinct hues (blue, green and purple) by manipulating their pigment and protein binding systems, and show that this is a wider trait across the genus.</p>
15:00	915	<p style="text-align: center;">Formation of biophotonic gyroid nanostructures in the butterfly <i>Parides sesostris</i></p> <p style="text-align: center;"><i>Anna-Lee Jessop^{1,2}</i> ¹ University of Salzburg, Austria, ² Murdoch University, Perth, Australia</p> <p>Nature provides many remarkable examples of complex functional materials. Such examples include the biophotonic gyroid nanostructures found in butterflies. These biological nanostructures exhibit uniquely desirable optical properties but form at a length scale that we are currently unable to easily replicate. In this study we aimed to elucidate the formation mechanisms of gyroid nanostructures in the butterfly <i>Parides sesostris</i>. We used in vivo hyperspectral microscopy on living pupae to observe changes in reflectance that occur due to gyroid nanostructure development and combined this with post-mortem electron microscopy. We show that the structure forms as an entanglement of fibres woven into a gyroid that is templated by cellular membranes and that this produces a red-shifted optical signal that increases over time.</p>

15:15	916	<p style="text-align: center;">Mutanofactin affects interactions of mucin-coated surfaces and <i>Streptococcus mutans</i></p> <p style="text-align: center;"><i>Konstantin Nikolaus Beitzl¹, Leon Gabor Sacha Thies², Lukas Lüthy³, Moritz Hansen³, Joshua McManus³, Muhammad Afzal², Lukas Schrangl⁴, Susanne Bloch², Guruprakash Subbiahdoss¹, Erick M. Carreira³, Christina Schäffer², Erik Reimhult¹</i></p> <p style="text-align: center;">¹ <i>Institute of Colloid and Biointerface Science, BOKU University, 1190 Vienna, Austria</i> ² <i>Institute of Biochemistry, BOKU University, 1190 Vienna, Austria</i> ³ <i>Department of Chemistry and Applied Biosciences, Laboratory of Organic Chemistry, ETH Zürich, 8093 Zürich, Switzerland</i> ⁴ <i>Institute of Biophysics, BOKU University, 1190 Vienna, Austria</i></p> <p>Mucin is a glycoprotein and a major component of the salivary pellicle, forming protective layers against the adhesion of bacteria in the human oral cavity. Nevertheless, pathogens like <i>Streptococcus mutans</i> (<i>S. mutans</i>) adhere to this highly hydrated surface and initiate the formation of dysbiotic biofilms. Mutanofactins (Muf) were recently identified as small-molecule secondary metabolites of <i>S. mutans</i> that promote the formation of such biofilms, supposedly through increasing cell surface hydrophobicity (CSH). However, we rule out any direct effects on CSH. Instead, quartz crystal microbalance with dissipation monitoring (QCM-D) and atomic force microscopy (AFM) measurements reveal that Muf-697 irreversibly changes the conformation of adsorbed mucin to promote <i>S. mutans</i> adhesion. This unique property of Muf-697 might be key to the early stages of biofilm formation in the human oral microbiome.</p>
15:30		END

ID	BIOPHYSICS AND SOFT MATTER POSTER	
931	<p style="text-align: center;">Optical Performance of Cylindrical and Tapered Fly Rhabdomeres Using a Cascaded Waveguide Approach</p> <p style="text-align: center;"><i>Mahdi Khodadadi Karahroudi, Primož Pirih, Bodo Wilts</i> <i>Department of Chemistry and Physics of Materials, Paris Lodron University of Salzburg, Austria</i></p> <p>Insect vision often relies on waveguides to enable vision. This study investigates light propagation in fly rhabdomeres, their lightguides, using a cascaded waveguide modeling approach. By dividing the rhabdomere into axial segments, we simulate the evolution of guided modes along the photoreceptor length. We compare rhabdomeres with cylindrical and tapered geometries to evaluate differences in mode excitation, power confinement, and light propagation behavior. The approach enables tracking of modal amplitude and phase across structural transitions, providing insight into how geometry influences optical performance. Tapering significantly alters the modal structure and can enhance or suppress specific modes. This flexible, biologically relevant framework aids in analyzing light flow in compound eyes and contributes to understanding structure-function relationships in insect vision.</p>	
932	<p style="text-align: center;">Atomic Force Microscopy (AFM) Analysis of Cellular Mechanics Following Measles Vaccine Virus Infection</p> <p style="text-align: center;"><i>Alexander Einschütz López¹, Johanna Bacher², Alois Jungbauer², José L. Toca-Herrera¹</i> ¹ <i>Institute of Biophysics, Department of Natural Sciences and Sustainable Resources, BOKU Wien, Austria,</i> ² <i>Institute of Bioprocess Science and Engineering, Department of Biotechnology and Food Science, BOKU Wien, Austria</i></p> <p>The measles virus (MeV) disrupts cellular functions by compromising cytoskeletal integrity. To examine its biomechanical effects, we studied Vero cells using atomic force microscopy (AFM) for force–distance and stress relaxation measurements. Our analysis showed a significant reduction in cell stiffness and prolonged stress relaxation times following MeV infection, indicating disruption of the actin and microtubule networks. These findings enhance our understanding of the biomechanical alterations induced by MeV and highlight potential targets for therapeutic intervention to mitigate virus-driven cellular damage.</p>	

933	<p style="text-align: center;">Understanding Biological Material Mechanics Through Energy Dissipation</p> <p style="text-align: center;"><i>Jose Luis Toca-Herrera ², Andreas Weber ¹</i></p> <p style="text-align: center;">¹ <i>London Centre for Nanotechnology, University College London, England,</i> ² <i>Institute of Biophysics, BOKU University, Vienna, Austria</i></p> <p>Biological materials are made of complex networks of proteins, lipids, carbohydrates, and other biomolecules. As a result, they display rich and complex viscoelastic behavior. Recent work has aimed to describe these properties at the nano- and microscale using linear and nonlinear models. However, selecting the appropriate model and its level of complexity remains challenging. Here, we use atomic force microscopy (AFM)-based force spectroscopy across a wide range of frequencies and indenter geometries to study energy dissipation (hysteresis) during compression–relaxation cycles. We examine cells, bacteria, and hydrogels. Hysteresis shows a power-law dependence on frequency. We propose this simple and accessible framework as a powerful tool to characterize viscoelastic behavior in biological materials and discuss its implications for understanding cell mechanics.</p>
934	<p style="text-align: center;">Rheo-microscopy of Soft Materials</p> <p style="text-align: center;"><i>Eva Hudec ^{1,2}, Nikolaos Kalafatakis ¹, Roberto Cerbino ¹</i></p> <p style="text-align: center;">¹ <i>Computational and Soft Matter Physics, Faculty of Physics, University of Vienna, Austria,</i> ² <i>Department of Physics, Faculty of Science, University of Zagreb, Croatia</i></p> <p>We investigate how microscopic dynamics underpin the bulk rheological behavior of soft materials by integrating microscopy with rheological measurements. By adapting a commercial rheometer for in situ imaging, we visualize structural rearrangements during deformation and recovery. Using echo protocols and recovery rheology, we probe viscoelastic behavior in both commercial and custom samples. Particle tracking and differential dynamic microscopy (DDM) enable us to correlate macroscopic mechanical responses with microscopic motion across different timescales and length scales. This work moves us closer to the rheologist's dream: directly observing the structures responsible for flow and deformation.</p>
935	<p style="text-align: center;">Non-Universality of Jamming in Cellular Monolayers</p> <p style="text-align: center;"><i>Jasmin Di Franco ^{1,2}, Fabian Krautgasser ¹, Camillo Mazzella ³, Fabio Giavazzi ⁴, Giorgio Scita ^{3,5}, Roberto Cerbino ¹</i></p> <p style="text-align: center;">¹ <i>Computational and Soft Matter Physics, Faculty of Physics, University of Vienna, Austria,</i> ² <i>Vienna Doctoral School in Physics, University of Vienna, Austria,</i> ³ <i>IFOM, The FIRC Institute for Molecular Oncology, Milan, Italy,</i> ⁴ <i>Department of Medical Biotechnology and Translational Medicine, Milan, Italy,</i> ⁵ <i>Department of Oncology and Haemato-Oncology, University of Milan, Italy</i></p> <p>Phase transitions in cellular collectives, such as jamming, play key roles in biological processes like morphogenesis and wound healing. While traditionally linked to increasing cell density, recent evidence suggests that adhesion forces also influence collective arrest. Our study examines jamming across epithelial and fibroblast cell lines using Particle Image Velocimetry (PIV) and Differential Dynamic Microscopy (DDM). We find significant variability in dynamical behaviors, with some monolayers slowing gradually while others transition from ballistic to diffusive motion. Crucially, motility transitions often correlate with spatial ordering, reflected in the static structure factor. These differences emerge both between and within cell types, challenging the idea of universal jamming. Our findings highlight the need for cell-type-specific frameworks to describe collective arrest in living tissues.</p>
936	<p style="text-align: center;">Rheomicroscopy of hydrogels across the yielding transitions</p> <p style="text-align: center;"><i>Sakshi Khandelwal ^{1,2}, Mohandas Mohandas ^{1,2}, Nikos Kalafatakis ^{1,2}, Roberto Cerbino ¹</i></p> <p style="text-align: center;">¹ <i>Computational and Soft Matter Physics, Faculty of Physics, University of Vienna, Austria,</i> ² <i>Vienna Doctoral School in Physics, University of Vienna, Austria</i></p> <p>Hydrogels are soft, water-rich polymer networks with widespread applications in biomedicine, soft robotics, and materials engineering. Understanding their mechanical behavior – particularly yielding, the strain amplitude at which their response transitions from solid-like to fluid-like – is essential for improving their reliability and performance. Here, we present preliminary rheomicroscopy results on a model hydrogel system, obtained using both a commercial and a custom-built rheometer. Our approach, combining classical rheological measurements with simultaneous quantitative microscopy, elucidates how the material responds to applied stress and highlights the onset of mechanical failure. These observations provide insight into the gel's stress-bearing capacity and lay the groundwork for future strategies to enhance its mechanical resilience and functional adaptability in application-oriented contexts.</p>

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Cell response to curvature gradients

Parvathy Anoop, Heidi Pertl-Obermeyer, Andreas Roschger, John Dunlop, University of Salzburg, Austria

Cells actively sense and respond to their surroundings. These responses can be triggered by biochemical signals as well as physical cues. Physical signals include substrate stiffness, compressive forces, or shear stress. Recent research has highlighted the significance of another key physical factor: substrate curvature. Previous studies in the group reveal that pre-osteoblast MC3T3-E1 cells grown on capillary bridges show a twisted plywood like structure. Micropatterning techniques have been widely used to constrain cell adhesion areas on 2D surfaces. While micropatterning is optimised for 2D surfaces, methods for controlled curvature study on 3D structures remain to be explored. This poster explores techniques to combine 2D patterning techniques on 3D printed surfaces to study cell alignment, movement and growth.

938

cancelled

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Cavitation on metallic implants induced by alternating magnetic fields disrupts bacterial biofilms but damages osteoblast-like cells

*Konstantin Nikolaus Beitzl, Guruprakash Subbiahdoss, Erik Reimhult
Institute of Colloid and Biointerface Science, BOKU University, 1190 Vienna, Austria.*

Implant-associated infections present a significant clinical burden. Traditional treatments range from prolonged antibiotic therapy to surgical removal of the implant. Novel physics-based therapeutic strategies like the application of alternating magnetic fields (AMF) promise to eradicate implant-associated infections non-invasively via localized inductive heating on metallic implants. We investigated the effects of AMF on *Staphylococcus aureus* biofilms and layers of SaOS-2 osteosarcoma cells on titanium surfaces. Our results suggest that the mechanism of AMF-induced biofilm disruption extends beyond thermal effects and likely involves mechanical forces from cavitation. Fast microbubble formation and cavitation generate intense shear forces through phenomena such as microjet impingement and microstreaming. These lead to irreversible structural damage and induce apoptosis in SaOS-2 cells, even for short AMF exposures. Our findings underline the importance of considering mechanical stress caused by cavitation to balance biofilm eradication with tissue safety when treating bacterial infections of metallic implants with AMF.