BP 28: Cytoskeleton

Time: Thursday 9:30–13:00 Location: H 2032

BP 28.1 Thu 9:30 H 2032

Actin waves as key functional structures of topological guidance and curvature sensing — •Cristina Martinez-Torres, Alexandra Faber, and Carsten Beta — Institute of Physics and Astronomy, University of Potsdam, Potsdam, Germany

The motility of cells in complex environments plays a crucial role in many biomedical processes such as wound healing or cancer metastasis. While the social amoeba *D. discoideum* is a well-known model organism to study pseudopod-based amoeboid motility, they can also move in a highly persistent motion reminiscent of keratocytes, where cells conserve a fan-shaped morphology. The occurrence of fan-shaped cells is intrinsically linked to the presence of actin waves, which are traveling wave patterns that propagate along the cortex, contributing to protrusion-driven cell motility. Here, we study the migration of single cells on micropillars of different geometries, and we investigate the interplay of topological guidance and curvature sensing. We show that when cells are able to form actin waves, the cells migrate preferentially along the edge of the pillar surface. This curvature-guided movement is persistent and occurs for curvatures comparable to the cell size, and also for different pillar geometries (circular, triangular, rectangular). However, when the preferred motility mode is that of an amoeboid cell without actin waves, the cells show no preference for tracking the edge of the pillar surface. Our results suggest that the topological guidance via actin wave formation is therefore critical for the edge-tracking migration.

BP 28.2 Thu 9:45 H 2032

Transient contacts between filaments bestow its elasticity to branched actin — Mehdi Bouzid[1,2], Cesar Valencia Gallardo[3], Magdalena Kopec[3], Giuseppe Foffi[4], Julien Heuvingh[3], Olivia du Roure[3], and •Martin Lenz[2,3] — [1]3SR, CNRS, Université Grenoble Alpes, France — [2]LPTMS, CNRS, Univ. Paris-Sud, Université Paris-Saclay, 91405 Orsay, France — [3]Laboratoire de Physique et Mécanique des Milieux Hétérogènes, UMR 7636, CNRS, ESPCI Paris, PSL — [4]LPS, CNRS, Univ. Paris-Sud, Université Paris-Saclay, 91405 Orsay, France

The biologically crucial elasticity of actin networks is usually understood as an interplay between the bending and stretching of its filaments. This point of view however fails when applied to the weakly coordinated branched actin networks found throughout the cell. Through experiments and theory, we show that their elasticity crucially involves reversible entanglements between their filaments. These entanglements can in turn be controlled during network growth to regulate the final properties of the network. These properties could be key to understanding how moving cells dynamically adapt their cytoskeleton to their environment.

BP 28.3 Thu 10:00 H 2032

Actin filament length is crucial in mesenchymal migration but not in amoeboid migration — •Carsten Baltes[1], Friederike Nolle[1,2], Kathi Kaiser[1], Erbara Gjana[1], Kristin Sander[1], Karin Jacobs[1,2], and Franziska Lautenschläger[1,2] — [1]Experimental Physics, Saarland University, Saarbrücken, Germany — [2]Center for Biophysics, Saarbrücken, Germany

The ability of cells to move is critical for a wide variety of cellular tasks inlcuding the search of immune cells for pathogens and the reorganization of cells in tissue development. The cytoskeletal protein actin is important for cellular migration as it is involved in its underlying mechanics. Alterations of the actin network therefore might have an impact on the migratory behaviour of cells.

Here, I present the effects of the stabilisation and elongation of actin filaments on migrating RPE-1 cells. I will show that mesenchymal migrating cells move at lower speed, while amoeboid migrating cells do not change their behaviour.

Cells with longer and more stable actin filaments have more but smaller focal adhesions. To test the effect on adhesion properties, we performed single-cell force spectroscopy. Cells with smaller focal adhesions showed lower adhesion strength and energy, suggesting that actin filament length is important for adhesion-based migration but negligible for friction-based migration.

This work emphasizes the different role of actin in mesenchymal versus amoeboid migration and adhesion and might help to influence all processes involving migration.

15 min. break

Invited Talk BP 28.4 Thu 10:30 H 2032

Quantifying the actin cortex of cells in different states — •Franziska Lautenschläger[1], Daniel Flormann[1], Christoph Anton[1], and Rhoda Hawkins[2] — [1]Saarland University — [2]AIMS Ghana, Accra

The actin cortex defines the shape of cells and is involved in a plethora of cellular functions. We aim to describe, predict and alter changes in cellular states by alterations of the actin cortex. I will show two examples of changes of a cellular states and their corresponding cortex alterations: An adhered cell compared with a suspended cell and a single cell compared with a cell in a monolayer. The parameters we chose to describe the actin cortex are the thickness, the mesh size, the bundling as well as the stiffness of the actin cortex. We compare our data of the actin cortex in cells with earlier theoretical and in vitro work and test theoretical predictions.

BP 28.5 Thu 11:00 H 2032

Cytoskeletal Networks in Cells Under Strain — •Ruth Meyer[1], Marie Tersteegen[1], Anna V. Schepers[1], Peter Luley[1], Ulrike Rölleke[1], Nicole Schwarz[2], Jonathan Bodenschatz[3], Amaury Perez Tirado[3], Andreas Janshoff[3], and Sarah Köster[1] — [1]Institute for X-Ray Physics, University of Göttingen — [2]Institute of Molecular and Cellular Anatomy, RWTH Aachen University — [3]Institute of Physical Chemistry, University of Göttingen

The cytoskeleton of eukaryotes consists of three types of filaments: F-actin, microtubules and intermediate filaments (IFs). In contrast to microtubules and F-actin, IFs are expressed in a cell-type specific manner, and among them keratins are found in epithelial cells. In certain cell types, the keratin IFs form a layer close to the membrane which may be referred to as an "IF-cortex". Furthermore, it is hypothesized that this IF-cortex arranges with radial spokes in a "rim-and-spokes" structure in epithelia. Based on this hypothesis, IFs and actin filaments might add complementary mechanical properties to the cortex. It was previously shown that single IFs in vitro remain undamaged even at high strains. We now ask the question of whether this unique force-extension behavior of single IFs is also relevant in the filament network within a cell. Here, we show the influence of equibiaxial strain on wild-type and keratin-deficient cells comparing the mechanical properties and the structure of actin and IF networks close to the cell membrane. We find an increase of cell stiffness and compressibility while fluidity and tension decrease during stretching.

BP 28.6 Thu 11:15 H 2032

The cytoskeleton positions protein condensates — •Thomas J. Böddeker[1,2], Roland L. Knorr[2], and Eric R. Dufresne[1,3] — [1]ETH Zürich, Zürich, Switzerland — [2]Humboldt-Universität zu Berlin, Berlin, Germany — [3]Cornell University, Ithaca, USA

Protein condensates inside human cells are liquid-like droplets composed of protein and RNA. These condensates interact with the heterogeneous, active and dense environment of the cytoplasm, crossed by various cytoskeletal filaments such as microtubules and actin. Capillary interactions with the cytoskeleton lead to stereotypical positioning of such protein droplets inside the cell. Using statistical physics approaches, we identified complementary functions of filamentous actin and microtubules for the positioning of such condensates: protein condensates couple to actin's native dynamics in the cell through steric interactions leading to directional motion towards the cell center. Microtubules (and their molecular building-blocks), on the other hand, act as Pickering agents and engage in energetically favorable wetting interactions that lead to a robust localization of protein condensates in microtubule-rich regions of the cell. Cytoskeletal filaments, in turn, deform in response to capillary forces, leading to network modulations centered on protein condensates. These mutual interactions are non-specific and ultimately arise from different affinities (contact angles) between condensate and filament, suggesting that similar mechanisms may impact localization of other liquid-like phases within the cell and structure formation within the cytoskeleton.

T.J. Böddeker, et. al. PRX Life, in press

BP 28.7 Thu 11:30 H 2032

Vimentin Secretion and its influence on macrophage functionality — •Divyendu Goud Thalla — Experimental Biophysics,Universität des Saarlandes, Saarbrücken, Germany

Macrophages play a vital role in the immune system by detecting and eliminating bacterial organisms through phagocytosis. Upon activation, macrophages expose vimentin cytoskeletal protein to the extracellular environment. Such extracellular vimentin can either remain bound to the cell surface or it can be released*into extracellular space. This phenomenon similarly occurs under circumstances like injury, senescence, and stress. However, the characteristics of the extracellular form of vimentin and its implications on macrophage functionality remain unclear. In this study, we demonstrate that vimentin is released from the back end of macrophages. Activation of macrophages further enhances this polarized secretion of vimentin. Our findings from migration and phagocytosis assays show that extracellular vimentin enhances macrophage functionality in terms of migration and phagocytosis. Through high resolution fluorescence microscopy and scanning electron microscopy techniques, we show that extracellular vimentin is released into extracellular space in the form of small fragments.Taken together, we propose a mechanism of vimentin secretion and its implications on macrophage functionality.

15 min. break

BP 28.8 Thu 12:00 H 2032

Lattice dynamics in microtubules: Revealing the dual effects of Tau in vitro — Subham Biswas[1], Rahul Grover[2], Cordula Reuther[2], Mona Grünewald[1], Karin John[3], Stefan Diez[2], and •Laura Schaedel[1] — [1]Saarland University, Saarbrücken, Germany — [2]TU Dresden, Germany — [3]LiPhy, CNRS/UGA, Grenoble, France

Microtubules are dynamic cytoskeletal filaments that grow and shrink by tubulin addition or removal at their tips. In contrast, the microtubule lattice far from the tips was long considered to be static. The discovery of tubulin loss and incorporation along the lattice far from the tips - termed lattice dynamics - led to a paradigm shift and revealed a new dimension of microtubule dynamics. Although lattice dynamics occur spontaneously, there is increasing evidence that microtubule-associated proteins (MAPs) are involved in their regulation. Here, we show that the neuronal MAP Tau, which typically decorates axonal microtubules, stimulates tubulin incorporation into the microtubule lattice in reconstituted in vitro systems. We uncover a dual effect of Tau: while it leads to an overall stabilization of the microtubule lattice in the absence of free tubulin, it also induces lattice turnover. Our data show how lattice dynamics are regulated by cellular factors, similar to the dynamics at their tips.

BP 28.9 Thu 12:15 H 2032

Lattice dynamics in microtubules: Theoretically exploring the dual effects of Tau — Subham Biswas[1], Rahul Grover[2], Cordula Reuther[2], Mona Grünwald[1], •Karin John[3], Stefan Diez[2], and Laura Schaedel[1] — [1]Saarland University, Saarbrücken, Germany — [2]TU Dresden, Germany — [3]Liphy, CNRS/Université Grenoble-Alpes, Grenoble, France

Microtubules are key structural elements of living cells that are crucial for cell division, intracellular transport and motility. They are dynamic polymers, which grow and shrink by addition and removal of tubulin dimers at their extremities. Within the microtubule shaft, dimers adopt a densely packed and highly ordered crystal-like lattice structure, which is generally not considered to be dynamic. Recent experiments have shown that microtubules exhibit a lattice dynamics far away from the extremities. This dynamics manifests itself as localized incorporation of free tubulin into the microtubule shaft. Tubulin incorporation into the microtubule lattice can occur either spontaneously or facilitated by microtubule associated proteins such as molecular motors and severing enzymes. The neuronal protein Tau is the latest addition to the growing number of molecules known to stimulate turnover of the MT lattice. However, the origin and underlying mechanisms of Tau stimulated lattice turnover is yet unknown, since Tau is rather known to stabilize the MT lattice. Here, we theoretically explore potential mechanisms of Tau stimulated lattice turnover, consistent with experimental observations.

BP 28.10 Thu 12:30 H 2032

Scanning small-angle X-ray scattering on single cardiomyocytes: high resolution in reciprocal space — •Hendrik Bruns[1], Titus Czajka[1], Michael Sztucki[2], Sören Brandenburg[3], and Tim Salditt[1] — [1]Institut for Xray physics, University of Göttingen, Germany — [2]European Synchrotron Radiation Facility, Grenoble, France — [3]University Hospital Göttingen, Göttingen, Germany

Muscle contraction is driven by an ordered protein structure in the sarcomere which generates a macroscopic force by synchronized movement. The long-range order in the structure in combination with highly brilliant 4th generation synchrotron radiation enables measurements on single cardiomyocytes in an (ultra) small-angle X-ray scattering (USAXS, SAXS) geometry, with beam sizes comparable to the size of the cell. High spatial resolution in reciprocal space in combination with spatially resolved maps of cells helps to overcome the challenge that cardiac muscle tissue has so far been much less prone for diffraction studies compared to skeletal muscle or trabeculae. Our experiments reveal the structural organization of single cardiomyocytes. In particular, we are able to observe the myosin arrangement and the troponin spacing. The results open up a pathway to measurements of living cells during their contraction cycle, thus improving our fundamental understanding of cardiac muscle function.

BP 28.11 Thu 12:45 H 2032

Cytoskeleton flow-to-force — •Yoav G. Pollack, Nilay Cicek, Emily Klass, Pratima Sawant, Sarah Köster, Anne Wald, and Andreas Janshoff — University of Göttingen, Göttingen, Germany.

The cytoskeleton provides the cell with both structural integrity and the capability to continuously adjust shape to support functions such as crawling or squeezing through gaps. To gain insight into this process we study the motion of actin filaments driven by myosin motors. We aim to read active actin flow or contraction from reconstituted actomyosin networks in droplets and Giant Unilamellar Vesicles (GUVs) and solve the inverse problem to deduce the motion-generating force field. From the theory side, a solution to the inverse problem is obtained with some robustness to measurement noise via regularization. However, reading the flow from fluorescent images is an ongoing data analysis challenge. We try to bridge this gap between experiment and mathematical theory using simulations. These can reveal both the necessary experimental parameters for reading the flow (e.g. frame rate and image resolution), as well as ascertain the minimal requirements of an experimental setup of showing a coherent flow, such as actin anchoring points and whether an induced anisotropy is needed.

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