BP 39: Cytoskeletal Filaments II

Time: Friday 9:30–12:00 Location: SCH A251

BP 39.1 Fri 9:30 SCH A251

Mechanosensitive Self-Assembly of Myosin II Minifilaments — •Justin Grewe[1], Kai Weissenbruch[2], Martin Bastmeyer[2], and Ulrich S. Schwarz[1] — [1]Ruprecht Karl University Heidelberg, Germany — [2]Karlsruhe Institute for Technology, Germany

Self-assembly and force generation are two central processes in biological systems that usually are considered in separation. However, the signals that activate non-muscle myosin II molecular motors simultaneously lead to self-assembly into myosin II minifilaments as well as progression of the motor heads through the crossbridge cycle.

We investigate theoretically the possible effects of coupling these two processes. Our assembly model, which builds upon a consensus architecture of the minifilament, predicts a critical aggregation concentration at which the assembly kinetics slow down dramatically. The combined model predicts that increasing actin filament concentration and force both lead to a decrease in the critical aggregation concentration in addition to force decelerated myosin turnover. We benchmark our model, in particular the turnover, against in-vivo fluorescence recovery after photobleaching experiments we performed in different experimental conditions and find reasonable agreement with the model.

We suggest that due to these findings, myosin II minifilaments in a filamentous context couple self-assembly with force generation and by this effect might be in a critical state that reacts faster to varying conditions than in solution.

BP 39.2 Fri 9:45 SCH A251

Development of microtentacles in suspended cells upon weakening of the actin cortex — •Lucina Kainka[1,2], Reza Shaebani[2], Ludger Santen[2], and Franziska Lautenschläger[1,2] — [1]INM - Leibniz Institute for New Materials, Campus D2 2, 66123 Saarbrücken, Germany — [2]Saarland University, Physics Department, Campus E2 6, 66123 Saarbrücken, Germany

Circulating Tumor Cells (CTCs) pose a significant threat due to their role in metastasis: It has been proposed that CTCs are able to escape the blood stream and reattach to the tissue by the formation of so-called microtentacles (McTNs. McTNs are microtubule based membrane protrusions with a diameter of less than 1 μm and a length of tens of μm.

In CTCs the balance of the outward growing microtubule and the contractive forces of the actin cortex is disrupted enabling microtubules to form these kind of protrusions. Using cytoskeletal drugs which are targeting the actin cortex integrity we induce McTNs even in non-cancerous RPE1 cells. We investigate the presence of microtubules and actin as well as vimentin under those conditions. Furthermore, we established a statistic over the number and lengths of McTNs depending on different drug concentrations applied.

Further experiments on the dynamics of McTNs, especially during retraction after drug wash-out, give a better insight in the role of individual cytoskeletal elements.

BP 39.3 Fri 10:00 SCH A251

Balance of forces and torques in a mean-field approximation in mitotic spindles — •Arian Ivec[1], Iva Tolić[2], and Nenad Pavin[1] — [1]Department of Physics, Faculty of Science, University of Zagreb, Croatia — [2]Ruder Bošković Institute, Zagreb, Croatia

The mitotic spindle is a self-organized micro-machine composed of microtubules and associated proteins, which divides genetic material between its two nascent daughter cells. Forces exist in the spindle throughout mitosis and are crucial for spindle functioning in each phase. In metaphase, the mitotic spindle has a recognizable shape with a characteristic arrangement of microtubules. Microtubules extend from opposite spindle poles and interact with the chromosomes and with each other. Though a significant progress in understanding the mechanics of the spindle has been achieved, the question of force balance in the spindle is still open. We explore the force balance of the entire spindle by introducing a mean-field approach, in which discrete microtubule bundles in a certain region, together with forces and torques exerted by these bundles, are approximated by an averaged bundle. The model provides predictions for forces and torques in the spindle, and consequently it predicts the shape of the entire spindle, including the shapes of inner and outer bundles, which is compared with shapes observed in our experiments. Based on this information, we provide a mechanical explanation for the shapes of inner and outer bundles, including major differences between them. This approach provides comprehensive insight into forces and torques acting in the entire spindle, which are crucial for proper cell division.

BP 39.4 Fri 10:15 SCH A251

The kinesin-14, Ncd, drives the helical motion of microtubules around each other — •Laura Meissner[1], Aniruddha Mitra[2], Felix Ruhnow[3], and Stefan Diez[4] — [1]B CUBE - Center for Molecular Bioengineering, Technische Universität Dresden, 01307 Dresden, Germany — [2]Department of Physics and LaserLaB Amsterdam, Vrije Universiteit Amsterdam, Amsterdam, Netherlands — [3]School of Biosciences, University of Melbourne, Parkville, VIC 3010, Australia — [4]Cluster of Excellence Physics of Life, Technische Universität Dresden, 01062 Dresden, Germany

Within the mitotic spindle, several kinesin motors crosslink and slide microtubules. Some kinesins, including kinesin-5 and kinesin-14, have been shown to exhibit sideways components in their step cycles, but the impact of the resulting off-axis power strokes on motility and force generation in the spindle has not been studied so far. Here, we investigate kinesin-14, Ncd, driven sliding of crosslinked, fluorescently-labeled microtubules with a novel three-dimensional in vitro motility assay. We find that free microtubules, sliding in an antiparallel orientation on microtubules suspended between nanofabricated ridges, not only rotate around their own axis but also move around the suspended microtubules with right-handed helical trajectories. In contrast, microtubules crosslinked in parallel orientation are static with neither longitudinal nor helical motion. We argue that the capability of microtubule-crosslinking kinesins to cause helical motion of microtubules around each other allows for flexible filament organization, roadblock circumvention and torque generation in the mitotic spindle.

BP 39.5 Fri 10:30 SCH A251

Anillin Propels Myosin-Independent Constriction of Actin Rings — Ondřej Kučera[1], Daniel Janda[1], Valerie Siahaan[1], Sietske H. Dijkstra[1], Eva Zatecka[1], Stefan Diez[2,3], •Marcus Braun[1], and Zdenek Lansky[1] — [1]Institute of Biotechnology of the Czech Academy of Sciences, BIOCEV, Prague West, Czechia — [2]B CUBE - Center for Molecular Bioengineering, Technische Universität Dresden, 01307 Dresden, Germany — [3]Cluster of Excellence Physics of Life, Technische Universität Dresden, 01062 Dresden, Germany

Constriction of the cytokinetic ring, a circular structure of actin filaments, is an essential step of cell division. In a generally accepted view, the constriction is driven by relative sliding of actin filaments propelled by myosin motors. However, in multiple organisms, the ring constriction is myosin independent. How actin rings constrict in the absence of motor activity remains unclear. Here, we demonstrate that actin contractility can be propelled by anillin, a diffusible non-motor actin crosslinker, colocalising with the cytokinetic ring. We in vitro observed the formation and constriction of rings comprising multiple actin filaments bundled by anillin. Rings constricted due to anillin-driven maximisation of overlaps between the filaments. Actin disassembly promoted constriction. Optical trapping demonstrated that anillin molecules, crosslinking bundles of several actin filaments, collectively, generate forces of tens of pico-Newtons. We propose that diffusible non-motor actin crosslinkers, generating forces complementary to the activity of molecular motors, may contribute to the contractility of diverse actin structures, including the cytokinetic ring.

45 min. coffee break

BP 39.6 Fri 11:30 SCH A251

Active Model C: mean-field theory of cytoskeletal pattern formation — •Ivan Maryshev[1], Alexander Morozov[2], Davide Marenduzzo[2], and Erwin Frey[1] — [1]Ludwig-Maximilians-Universität München, Germany — [2]The University of Edinburgh, Edinburgh, EH9 3FD, UK.

The self-organization of mixtures of biological polymers and molecular motors provides a fascinating manifestation of active matter. Microtubules re-oriented by the molecular motors can form far-from-equilibrium cell-scale structures. The link between individual microscopic interactions of filaments and their macroscopic dynamics is

poorly understood. Here we formulate a theoretical approach based on a Boltzmann-like kinetic equation, to describe pattern formation in two-dimensional mixtures of microtubules and molecular motors. We consider motors that can push apart antiparallel microtubules and cluster parallel ones. Using our kinetic approach, we derive the equations governing the collective behavior of microtubules by rigorously coarse-graining microscopic motor-induced interactions. Through numerical simulations, we show that this model generically creates either stable stripes with the antiparallel arrangement of filaments inside them or an ever-evolving pattern formed by self-extend dynamic bands. Finally, we consider our model with phenomenological coefficients and besides the chaotic bands, also observe the formation of patterns with topological defects, including foams and asters. By the analogy with passive Model C in Hohenberg-Halperin classification, we call our model Active Model C.

BP 39.7 Fri 11:45 SCH A251

Buckling instability and active oscillations in a pair of clamped elastic filaments — •Andrej Vilfan[1,2], Laura Collesano[1], and Ramin Golestanian[1] — [1]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany — [2]J. Stefan Institute, Ljubljana, Slovenia

A pair of microtubules that are fixed at the proximal end and connected via dynein motors at the distal end can serve as a minimal synthetic system aimed at re-creating active oscillations resembling those of biological cilia. Here, we study theoretically the static shapes and the active dynamics of two connected filaments, modeled as flexible beams. We first determine the shape of a pair of elastic rods of different lengths with clamped ends (i.e., with coinciding endpoints and tangent vectors). Starting from equal lengths, the system first undergoes a transition similar to Euler buckling, however at a different critical load, and then assumes a planar shape. After a secondary bifurcation, the shape becomes non-planar with spontaneously broken chiral symmetry. At an even higher length ratio, it changes to planar again. To study the active system, we replace the passively clamped end with molecular motors exerting a tangential force with a given density in the overlap zone. The dynamical system can have a stable fixed point, with either bent or straight filaments, or limit cycle oscillations reminiscent of ciliary beating.