AKB 1 Cellular Processes

Time: Monday 09:45–11:30 Room: ZEU 255

Prize Talk AKB 1.1 Mon 09:45 ZEU 255

Biophysics of Cells: Active Matter in Motion — •Frank Jülicher — Max Planck Institut für Physik komplexer Systeme, Dresden — Träger des Robert-Wichard-Pohl-Preises

A fascinating feature of living cells is their inherently dynamic nature which is exemplified by the ability to generate spontaneous motion. A prototype system to study dynamics and active processes in cells is the cytoskeleton, a complex gel-like filament network which governs the material properties of cells. Complex cellular dynamics is driven by active processes on the molecular scale, for example the action of motor molecules. On the cellular scale, this activity can result in new material properties, emergent collective modes and spontaneous movements which play an important role for processes such as cell locomotion and cell division. Active cellular processes are also directly involved in the amplification of mechanical vibrations by sensory cells of our ear. The nonlinear and active properties of this cellular amplifier are essential to endow the ear with its exquisite abilities to detect sound.

AKB 1.2 Mon 10:30 ZEU 255

Mechanics and dynamics of actin ring constriction during cytokinesis: The role of filament polymerization — •Alexander Zumdieck, Karsten Kruse, and Frank Jülicher — MPI-PKS, Nöthnitzer Str. 38, Dresden

The cytoskeleton is a complex network of protein filaments. Driven by active processes such as filament polymerization and depolymerization and the action of molecular motors it represents an active, soft material. It is intrinsically dynamic and able to generate mechanical stress and flow of filaments.

We present a theoretical description of the dynamics and mechanics of contractile actin rings, important cytoskeletal structures, which constrict cells during cytokinesis. Quantitative comparison of experimental data together with a phenomenological description of ring contraction allows us to estimate the essential parameters characterizing mechanics and dynamics of a contracting ring. We discuss in particular the cell elastic modulus, the mechanical stress generated by the ring as well as the filament density in the ring and the rates of filament turnover.

Using a more microscopic description of filament interactions in the ring, we identify physical mechanisms of ring contraction driven by motors and filament turnover. In particular we discuss how filament bundles may generate tension in the absence of molecular motors.

AKB 1.3 Mon 10:45 ZEU 255

Spatio-temporal protein dynamics in rod-shaped bacteria — •Elisabeth Fischer, Giovanni Meacci, and Karsten Kruse — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str.38, 01187 Dresden

In the bacterium E.coli, positioning of the division plane involves oscillations of the Min-proteins form one cell pole to the opposite. We study a possible mechanism underlying the oscillations by usage of a coarse-grained description in terms of partial differential equations. The analysis of the dynamics in a three-dimensional geometry akin to the bacterial shape shows oscillations that are reminiscent of the oscillations observed experimentally. In addition, we find several other dynamic states including traveling waves. Furthermore, we discuss the influence of noise on the oscillation pattern and compare our results to experiments.

AKB 1.4 Mon 11:00 ZEU 255

By chance or by the clock: How do concentrations in cells oscillate? — •Martin Falcke and Alexander Skupin — Abteilung Theorie SF5, Hahn Meitner Institut, Berlin

Intracellular concentration oscillations can be deterministic limit cycle oscillations or can be driven by fluctuations in a non-oscillatory dynamic regime. The cause of oscillations of intracellular Ca^{2+} concentrations was discussed on theoretical grounds in the last 2-4 years. We present experimental data very much in favor of one of the mechanisms and substantiate them with theoretical results.

AKB 1.5 Mon 11:15 ZEU 255

The precision of genetic oscillators and clocks — •Luis G. Morelli and Frank Jülicher — Max Planck Institut für Physik komplexer Systeme, Nöthnitzer Str. 38 (01187) Dresden, Germany

Genetic oscillations play a major role in different cellular processes, for example in circadian clocks, during the cell cycle, and patterning in developing embryos. Due to the stochastic nature of gene expression, the period of these oscillations is subject to fluctuations. The precision of the oscillator can be characterized by the quality factor. We study the precision of genetic oscillators in a simple but general stochastic feedback system. We show that high quality is possible for certain parameter ranges even when the number of molecules is low and amplitude fluctuations are large. We relate our results to circadian clocks in bacteria, where high quality oscillations have been observed in single cell experiments.