BP 29: Posters: Regulation

Time: Thursday 17:30–19:30 Location: Poster A

BP 29.1 Thu 17:30 Poster A

Autocatalytic processes in primordial reactions — •Sabrina Scherer — Universität des Saarlandes, Biologische Experimentalphysik

Stanley L. Miller made a revolutionary experiment in 1952. He discovered amino acids in a reaction of methane, ammonia, hydrogen and water, triggered with electric discharges and heat. We reproduced Miller's experiment to understand the physical and chemical processes, which take place in the first biochemical reactions. Catalysts lead to the selection of specific reactions and push the corresponding reaction rates. To analyse the samples we use mass spectrometry. In our spectra, we detect two different states. One of them consists of hundreds of different masses. In contrast, the other state displays well-ordered spectra with many equidistant peaks. The alternating appearance of these two states over time points to a competing system in which several catalytic cycles could be involved. We suspect self-reproductive and autocatalytic cycles to play a significant role in chemical evolution.

BP 29.2 Thu 17:30 Poster A

Evolution of increasingly complex molecules — •Philipp Zimmer[1], Emanuel Worst[2], Eva Wollrab[2], Albrecht Ott[2], and Karsten Kruse[1] — [1]Universität des Saarlandes, Theoretische Biologische Physik, Postfach 151150, 66041 Saarbrücken — [2]Universität des Saarlandes, Biologische Experimentalphysik, Postfach 151150, 66041 Saarbrücken

Darwinistic evolution of species started on the level of molecules. It is still unknown under which conditions evolution of molecules of increasing complexity can occur in chemical mixtures that are out of thermodynamical equilibrium. We examine a simple scenario, in which molecular units assemble into chains either by spontaneous or by template-driven, assisted concatenation. We show that, beyond a critical rate of assisted concatenation, the fractions of chains of increasing length grow exponentially. An experimental realization of this system is proposed.

BP 29.3 Thu 17:30 Poster A

Atomspektren gewonnen aus einem zellbiologischen Mechanismus — •Manfred Kunz — Reinhardtstraße 11, 04318 Leipzig

Spektren werden aus Übergangsenergien berechnet. Man kann diese ohne direkte Bezugnahme auf die Atomphysik berechnen, wozu lediglich die Masse des Elektrons mit Atomkern und die Feinstrukturkonstante in einer relativistischen Interpretation gebraucht werden. Vorausgesetzt werden Teilchen oder relativistische Scheinmassen, deren Wechselwirkung unter Anwendung der Erhaltungssätze für Energie und Impuls mit ganzen Zahlen zu Spektralserien führen. Die Hinzunahme biologischer Mechanismen erweist sich als hilfreich. Eine modifizierte Keimzellteilung lässt sich auf eine Dreiecksmatrix mit einheitlichen Gliedern reduzieren. Bezeichnet man die Anzahl der Zeilen mit n, dann erfolgt der Wachstumsvorgang im Prinzip durch Kopieren der vorausgegangenen Dreieckszeile und durch ein symmetrisches Anfügen je eines weiteren einheitlichen Gliedes. Jede Dreieckszeile soll aus 2n-1 Gliedern bestehen, das Dreieck beinhaltet demzufolge insgesamt n^2 Glieder. Bei der Lyman-Serie repräsentiert die längste Dreieckszeile zahlenmäßig den Impuls P. Der Gesamtinhalt des Dreiecks verkörpert die Energie E. Die Größen P und E sind nicht frei wählbar. Jede Dreieckszeile lässt sich anordnen als ein räumlich übereinander liegendes Sternpolygon oder Polygon, entfernt vergleichbar mit einer Bohrschen Bahn. Die Glieder können als Punkte eines interessanten Algorithmus belebt werden.

BP 29.4 Thu 17:30 Poster A

Reversible Enzyme Regulation as a Source of Bistability in Covalent Protein Modification Systems — •Ronny Straube and Carsten Conradi — Max Planck Institute for Dynamics of Complex Technical Systems, Magdeburg, Germany

Goldbeter and Koshland have shown that covalent protein modifications can generate highly sigmoidal response behavior (known as ultrasensitivity) when the converter enzymes (e.g. kinase and phosphatase) operate in saturation [1]. However, in vivo, the converter enzymes are often themselves subject to regulation, e.g. by an allosteric effector or by additional covalent modifications. As a result, they typically exist in inter convertible states of high and low activity which may compete for substrate. Here, we show that this competition is structurally sufficient to generate a bistable system response already at the level of a single protein modification cycle, i.e. without the requirement for multisite modifications or additional positive feedback loops. In contrast to mechanisms based on multisite modifications bistability is even predicted to occur when substrate molecules and enzymes are present in equal amounts. Our results provide an alternative and challenging view on the origin of bistability in the Cdk1-Cdc25-Wee1 system [2] which governs the M-phase transition of the cell cycle in fission yeast.

[1] Goldbeter A, Koshland, DE Jr. An amplified sensitivity arising from covalent modification in biological systems. Proc. Natl. Acad. Sci USA 78, 6840-6844 (1981). [2] Ferrell JE Jr. Feedback regulation of opposing enzymes generates robust, all-or-none bistable responses. Curr. Biol. 18, R244 (2008).

BP 29.5 Thu 17:30 Poster A

Cell polarisation's impact on local and global calcium signals during T-cell activation — •Martin Peglow and Heiko Rieger — Universität des Saarlandes

A crucial step for the successful T-cell activation is the stimulation of calcium (Ca^{2+}) entry across the plasma membrane through the so called Ca^{2+} release-activated Ca^{2+} (CRAC) channel. Recently Quintana et. al (The EMBO Journal (2011) 30, 3895 - 3912) have shown, that cell polarisation (the rearrangement of several cell organelles) is a very important step in T-cell- and CRAC-channel-activation. With our model we want to verify if different relativ positions between CRAC-channels, mitochondria and plasma membrane calcium-ATPases (PMCA)-pumps are sufficient to explain the different Ca^{2+} -signals in T-cells. And indeed we can shown, that mitochondria near to the CRAC-channel lead to a higher global Ca^{2+}-concentration and a lower Ca^{2+} microdomain near the CRAC-channel. A nice result is, that an accumulation of PMCA-pumps near the CRAC-channel is essential for high global Ca^{2+}-signals and so for T-cell activation and that in contrast a uniform distribution of PMCA-pumps in the PM lead to lower cytosolic Ca^{2+} -signals. This prediction should be investigated in some new experiments.

BP 29.6 Thu 17:30 Poster A

Molecular Mechanisms of Pattern Formation: Inward Rotating Spiral Waves in Glycolysis — •Ronny Straube[1] and Ernesto M. Nicola[2] — [1]Max Planck Institute for Dynamics of Complex Technical Systems, Magdeburg — [2]Institute for Cross-Disciplinary Physics and Complex Systems, Palma de Mallorca

We have recently observed a novel type of spiral wave behavior called inward rotating spiral waves or anti-spirals [1]. To elucidate the underlying molecular mechanism leading to this unusual wave behavior we compare two mechanisms of product activation for the allosteric enzyme phosphofructokinase using amplitude equations. We find that a sequential activation mechanism as in the Monod-Wyman-Changeux (WMC) model is able to generate inward propagating waves while a simple Hill function, as employed in the Selkov model, is not [2]. We show that the occurrence of inward propagating waves does not depend on the magnitude of the enzyme cooperativity (as is true for the occurrence of homogeneous oscillations), but on its sensitivity with respect to changes in the activator concentration. Our results provide an explicit example which shows how the macroscopically observable patterns in a spatially extended system depend on the molecular details of the underlying reaction mechanism.

[1] Straube R, Vermeer S, Nicola EM, Mair T (2010). Inward rotating spiral waves in glycolysis. Biophys. J. 99, L4-L6.

[2] Straube R, Nicola EM (2010). Diffusive coupling can discriminate between similar reaction mechanisms in an allosteric enzyme system. BMC Syst. Biol. 4:165.

BP 29.7 Thu 17:30 Poster A

Dynamics of bacterial persistence — •Pintu Patra and Stefan Klumpp — Max Planck Institute of Colloids and Interfaces Wissenschaftspark Golm 14424 Potsdam, Germany

Persistence is a survival mechanism of bacterial populations that allows them to tackle environmental stress such as antibiotic killing. The phenomenon is the result of reversible phenotype switching between two distinct phenotypic states which are characterized by slow and fast growth or decay. Therefore these cells generate two distinct

sub population during their evolution. We analyse the transient and evolutionary behaviour of a population consisting of two sub population, persister and normal cells, with reversible switching between the two phenotypes. We derive an analytical expression for the fitness of each sub population in fixed and varying environmental conditions. We calculate different time scales in which the total population evolves during its growth and decay which can be used to experimentally measure the phenotypic switching rates. Moreover we show that there is an evolutionary optimal phenotype switching rate for periodic environmental variations. We calculate the total population growth rate to map out the conditions under which the population grows or decays in periodically changing environments. Our study provides a theoretical underpinning for studying phenotypic switching.

BP 29.8 Thu 17:30 Poster A

Effects of receptor location and transport mechanism on bacterial quorum sensing — •Bastian Drees[1,2] and Ilka B. Bischofs[1,2] — [1]Zentrum für Molekulare Biologie der Universität Heidelberg, DKFZ-ZMBH Alliance, Im Neuenheimer Feld 282, 69120 Heidelberg, Germany — [2]BioQuant, Im Neuenheimer Feld 267, 69120 Heidelberg, Germany

In a process known as quorum sensing (QS) bacteria produce, secrete and sense autoinducer molecules (AI) to communicate and get information about their environment, such as cell density and the extent of AI loss by diffusion or flow. QS systems found in different bacteria differ in the way the AIs are secreted and in the way they are sensed. We theoretically investigate the sensitivity and robustness of different QS architectures and the environmental conditions under which these architectures show optimal sensing behavior. We find that active export barely has any effect on external sensing, while any kind of active transport (import or export) increases the noise in internal sensing systems. Furthermore, our model suggests that systems with extracellular sensors are preferred at low AI concentrations, while internal sensing might be preferred at intermediate AI concentrations; a result supported by experimental data.

BP 29.9 Thu 17:30 Poster A

Nonenzymatic Replication of Polynucleotides — •Benedikt Obermayer[1], Kevin Leu[2], Rebecca Turk[2], Sudha Rajamani[2], Irene Chen[2] und Ulrich Gerland[3] — [1]Department of Physics, Harvard University, Cambridge, USA — [2]FAS Center for Systems Biology, Harvard University, Cambridge, USA — [3]Ludwig-Maximilians-Universität München

In the early "RNA world" stage of life, RNA-like polynucleotides stored genetic information and catalyzed chemical reactions. Replication of such molecules suffers from high error rates, limiting the amount of information that can be reliably propagated. We study the fidelity of RNA and DNA replication using experimental non-enzymatic polymerization, and compare to lower bounds on these error rates calculated from a thermodynamic model. We find that RNA replication is intrinsically error-prone compared to DNA, suggesting that transitioning to DNA as genomic material could be of evolutionary advantage [1]. Moreover, we observe a strong context-dependence of polymerization rates, leading to a high probability of successive (cooperative) mutations and markedly slowed polymerization after mismatches. In an intriguing deviation from equilibrium expectations, these effects lead to a drastically lower effective error rate, alleviating its deleterious consequences.

[1] K. Leu, B. Obermayer, S. Rajamani, U. Gerland, I. A. Chen, Nucl. Acids Res. **39**:8135 (2011)

BP 29.10 Thu 17:30 Poster A

Quantum mechanical light in biological systems — •Michael Drexel, Fritz-Albert Popp, and Rajendra P. Bajpai — International Institute of Biophysics, Neuss

Light emanating from living systems ("biophotons") was analyzed and characterized as quantum mechanical, squeezed light. Methods for detecting ultra weak intensity (some photons per square-meter and second) at visible spectral region are described and measurements from biological samples like humans are shown. The three squeezed state parameters (r, Θ and Φ) are estimated for 10 bin sizes (50, 100, ..., 500 milliseconds) by merging the counts at contiguous bins of the observed signal. Coherency index of a signal was established, it can be estimated by a novel method for background corrected measurements, and its practicability to characterize and quantify the deviation from the squeezed state of signals are presented.

The noninvasive measurement of visible- spectral biophoton- signals can be used for reliable characterization and pointing out changes in quantum nature of all emitting systems, as for instance it is done for controlling recovering process of human health, which can be correlated with other physical body parameters like temperature.

A session of colorpuncture treatment improved the coherency indices of signals from different sides and provided relief to the subject suffering from multiple sclerosis. Both improvement of the coherency indices and relief were temporary. More lasting improvement in coherency indices required many sessions of treatment.