BP 34: Posters - Physics of *Physarum polycephalum* and Other Slime Molds (Focus Session)

Time: Tuesday 14:00–16:00 Location: P2-OG1

BP 34.1 Tue 14:00 P2-OG1

Analyzing the spatial positioning of nuclei in multinuclear giant cells — •Maike Stange[1], Marius Hintsche[1], Kirsten Sachse[1], Matthias Gerhardt[1], Angelo Valleriani[2], and Carsten Beta[1] — [1]University of Potsdam, Potsdam, Germany — [2]Max Planck Institute of Colloids and Interfaces, Potsdam, Germany

The spatial arrangement of organelles and other subcellular components plays a critical role for many functions of life at the cellular level. For example, during cell division, a proper distribution of cellular material onto the daughter cells is vital for their survival. Here, we study the spatial distribution of nuclei in artificial giant cells of the social amoeba *Dictyostelium discoideum*. We performed dual-color confocal imaging of cells that express fluorescence-labeled proteins for the nucleus and the microtubules. Based on this data, we determined the subcellular positions of nuclei, centrosomes, and their associated microtubules. A comparison with model predictions for random positioning in a confined domain suggests that nuclei in the giant cells are indeed randomly distributed, despite the putative steric interactions of neighboring microtubule cytoskeletons. Three-dimensional image reconstructions support our findings.

BP 34.2 Tue 14:00 P2-OG1

Inexpensive Observation System for Decision Experiments with *Physarum polycephalum* — •Ann-Marie Parrey[1], Nelly von Puttkamer[1,2], Anja Bammann[1], Adrian Fessel[1], Erik Bernitt[1], and Hans-Günther Döbereiner[1] — [1]Institut für Biophysik, Universität Bremen — [2]Hochschule Bremen

A low-priced observation system with automated temperature control and image capturing is presented. The setup is controlled by a Raspberry Pi and can be used for educational purposes. We demonstrate that with this system, the decision-making behaviour of slime molds such as *Physarum polycephalum* can be automatically observed.

Over a period of 24 hours a Raspberry Pi camera module inside the incubator takes pictures of a slime mold growing on an agar plate composed of two sides. One side contains a threat, i.e. salt, while the other side is neutral. The slime mold is prepared on an oatmeal flake and sits in the middle of the agar plate. Varying salt concentration, we observe a strong preference of the slime mold towards the neutral side for high salt concentrations, while this preference weakens for low concentrations. This behaviour can be explained assuming a two state system, where the salt side is represented by a higher energy state and the neutral side is associated with a lower energy state. With these assumptions, the probability $P_N(c)$ to find the slime mold on the neutral side can be calculated: $P_N(c) = 1/(e^{-kc}+1)$, with c as the salt concentration and a constant k, which is fit to the data. We find theoretically that $k = 1/\Omega\, \partial\Omega/\partial c$, i.e. the relative loss of the number of states Ω with increasing salt concentration.

BP 34.3 Tue 14:00 P2-OG1

Decision making in *Physarum polycephalum* as a basis for biomimetical solutions to optimization problems — •Nelly von Puttkamer[1,2], Ann-Marie Parrey[1], Anja Bammann[1], Adrian Fessel[1], Erik Bernitt[1], and Hans-Günther Döbereiner[1] — [1]Institut für Biophysik, Universität Bremen — [2]IS Bionik, Hochschule Bremen

Everyone of us is faced with multiple decisions daily, ranging from personal ones to those made on headquarters level. Quite often, although the probability of an unpleasant outcome or the impact is not known, making a decision is inevitable. Albeit humans are outfitted with a sophisticated neural system, there is a lot to learn about the biological basis of decision making from simpler life forms. Previous observations of *Physarum polycephalum*, a unicellular, multinucleate slime mold, demonstrated a higher complexity of decision making than expected for a non-conscious organism. In this work we show that, during foraging, the plasmodium of *P. polycephalum* takes a calculated risk, as present in the form of potassium chloride in the substrate. Risk was quantified by measuring the relative plasmodial area intruding regions with varying salt concentration. The corresponding probability was found to decrease with salt concentration. With a higher risk, the variances of the paths taken by the plasmodium decrease as well, hinting at a lower exploration of the substrate presenting a risk. These findings give an insight into decision making on the lowest level and without a central nervous system. We envision our findings to be useful in fields where risky decisions are inevitably made, for example in economics.

BP 34.4 Tue 14:00 P2-OG1

Indentation Analysis of Active Viscoelastic Microplasmodia of *P. polycephalum* — •Adrian Fessel[1], Christina Oettmeier[1], Ang Wei Tech[2], and Hans-Günther Döbereiner[1] — [1]Universität Bremen, Bremen, Deutschland — [2]Nanyang Technological University, Singapore

We present an analysis of force data obtained from indentation testing of vital microplasmodia of the slime mold *Physarum polycephalum*. Approximating the testing scenario as a layer tied to a rigid foundation leads to an estimation of Young's modulus at $E = (16.7 \pm 7.7)\,\mathrm{kPa}$, which is fairly consistent for various samples and for different time-dependencies of the indentation force. We observe variation of the modulus with the characteristic oscillation of *P. polycephalum*. Further we find a set of superimposed decay times during repeated indentation, which can be attributed to viscoelastic effects and the porous structure of microplasmodia. We demonstrate by extending the Kelvin-Voigt model to include non-linear effects and via FEM simulations, that apparent non-linearities in the stress-strain ellipsoids can be attributed to variations of sample thickness. A detailed theoretical description of the non-linear thickness effect is given in the contribution 'Non-Linear Compliance of Elastic Layers to Indentation' (BP 7.4).

BP 34.5 Tue 14:00 P2-OG1

Pruning to increase transport in *Physarum polycephalum* — •Sophie Marbach[1,4], Karen Alim[2,4], Nathalie Andrew[2,4], Anne Pringle[3], and Michael Brenner[4] — [1]Laboratoire de Physique Statistique, Ecole Normale Supérieure, Paris, France — [2]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany — [3]Departments of Botany and Bacteriology, University of Wisconsin-Madison, Wisconsin, USA — [4]School of Engineering and Applied Science, Harvard University, Massachusetts, USA

How do the topology and the geometry of a tubular network affect the spread of particles within fluid flows? We investigate the detailed physical forces responsible for mixing in the hierarchical, biological transport network formed by *Physarum polycephalum*. We introduce an efficient method to build patterns of effective dispersion, taking into account all the specificities of the individual. We demonstrate that a change in topology - pruning in the foraging state - causes a large increase in effective dispersion throughout the network. By comparison, changes in the hierarchy of tube radii result in smaller and more localized differences. Pruned networks capitalize on Taylor dispersion to increase the dispersion capability. It is fascinating to speculate that pruning in other biological systems, for example, during vessel development in zebra fish brain development [1] or during growth of a large fungal body [2], serve a similar objective of enhanced effective dispersion. Pruning itself might be triggered by the concentration of specific dispersing particles. Pruning is also tightly governed by the initial pattern of hierarchy, and the dynamic entanglement between hierarchy and pruning remains unsolved. Investigating the mechanisms allowing for pruning would be highly instructive in the process of understanding the overall organization of organisms, and is ongoing work.

[1] Chen, Q. et al., PLoS Biol. 10, e1001374 (2012)

[2] Smith, M. L., Bruhn, J. N., and Anderson, J. B., Nature, 356, 428 (1992).

For more details, Marbach, S. et al., Phys. Rev. Lett. 117, 178103 (2016)