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CASUS Institute Seminar

Controlling the Physics of Cellular Organization

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Date: Tuesday, 16 March 2021

Time: 14:00 – 15:00 CET

Location: CASUS Lecture Room, Görlitz

Abstract:

Imagine light microscopy became interactive like a computer game.

Rather than observing the miracles of cell biology hands tied, we'd be in control of the spatial dynamics and transformations that govern cellular organization and embryogenesis. We would understand how the cellular constituents feel like, how their material properties change under drug treatments, and how re-arrangements of chromatin impact cell identity. We were to provoke medically relevant phenotypes for research without changing cellular biochemistry, and we would assist early human development in reproduction clinics far beyond todays capabilities.

Towards this end, my lab pioneered the optical control of cytoplasmic motion, which we refer to as Focused-Light-Induced-Cytoplasmic-Streaming (FLUCS, commercialization initiated). Using FLUCS, we successfully gained interactive control of central developmental programs such as body axis formation in the C. elegans embryo. For example, our research established that cytoplasmic flows localize PAR proteins. This polarization process can be accelerated, spatially modulated, and even fully reversed via FLUCS leading to conclusive phenotypes downstream (Mittasch et al 2018, Kreysing 2019). Similarly, on the supra-molecular level, we recently succeeded to control phase-separation in space and time *(in preparation)*. As a non-invasive method, FLUCS furthermore enables to measure material properties, even through cell walls, while circumventing conceptual and technical problems of classic methods. Such rheological measurements can inform about the metabolic state of cells (Mittasch et al 2018) and permit to dissect functional material properties of organelles with respect to the underlying biochemical pathways and/or drug treatment (Mittasch et al, 2020). Recently, we found that FLUCS can successfully be applied also inside the cell nucleus. This finding motivates us to refine FLUCS for sub-diffraction micro-manipulations that we are currently working on. These might enable the induction of medically relevant phenotypes for cancer and developmental research. Furthermore, the non-invasive re-positioning of chromosomes might serve as a possible basis to assist earliest human development after in-vitro fertilization, such as to help the correct segregation of chromosomes to avoid human aneuploidies and developmental defects.

The ability to move chromatin inside living cells will furthermore help us to understand the biophysical mechanisms that promote retinal transparency (Solovei et al, 2009, Kreysing et al 2012, Subramanian et al 2019). This constitutes the starting point of our EU funded project to make living tissues transparent by genetics in order to facilitate high resolution microscopy of biological processes in their native *in vivo* contexts.