# Cortical wave patterns in giant *Dictyostelium* cells

Carsten Beta
Institute of Physics and Astronomy
Karl-Liebknecht-Str. 24/25
14476 Potsdam, Germany
beta@uni-potsdam.de

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Numerous cellular functions like cell motility, phagocytosis, and division depend on the coordinated formation of functional cytoskeletal structures that exhibit characteristic length and time scales. The underlying mechanisms that control the emergence of such subcellular patterns have attracted increasing attention over the past years. Here, we focus on self-organized wave patterns that emerge in the substrate-attached actin cortex of motile cells of the social amoeba *Dictyostelium discoideum*. We use electric pulse-induced cell fusion to generate giant polynuclear *Dictyostelium* cells that allow us to observe the wave patterns in a large spatially extended actin cortex, independent of confinement due to limited cell size [1]. We found that waves consist of a PIP3-rich band enclosed by an actin-rich border, i.e., they are composite structures involving both the actin cortex and the composition of the adjacent membrane. They travel across the substrate-attached membrane with a constant speed and display a self-organized width on the order of 10$\mu$m that remains constant independent of the cell size. Also the formation of rotating spiral waves was observed. Upon head-on collision, they mutually annihilate and, thus, show all the typical properties of an excitable system. Cortical waves also have a pronounced mechanical impact. When colliding with the membrane, they promote the formation of protrusions. Similarly, also subcellular structures like vacuoles can be directionally transported by the actin waves.

To investigate whether localized receptor stimuli can induce the spreading of excitable waves, we delivered spatially confined stimuli of the chemoattractant cAMP to the cell membrane [2]. To generate localized cAMP stimuli, either particles coated with covalently bound cAMP molecules were brought into contact with the cell membrane or a patch of the membrane was aspirated into a glass micropipette to shield this patch against freely diffusing cAMP molecules in the surrounding medium. By imaging the spatiotemporal dynamics of fluorescent markers for PIP3, PTEN and filamentous actin, we observed that the signaling activity remained spatially confined to the stimulated membrane region. Neighboring parts of the membrane that were not exposed to cAMP did not show any sign of excitation, i.e., no receptor-initiated spatial spreading of excitation waves was observed – a finding that can be explained on the basis of the local excitation/global inhibition (LEGI) mechanism of gradient sensing [3].

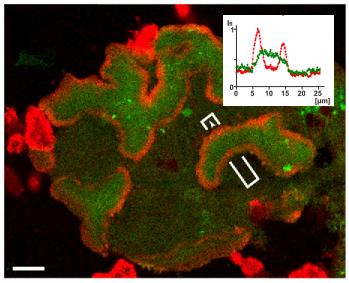

**Figure 1: Electrofused giant *Dictyostelium* cell expressing $PH_{CRAC}$-GFP, a green fluorescent label for PIP3, and LimE$\Delta$-mRFP, a red label for filamentous actin. Scale bar: 10 $\mu$m. Inset shows the fluorescence profile along the bar shown in the main panel. Modified from Ref. [1].**

This extended abstract summarizes an invited presentation delivered at PhysNet 2015.

## 1. REFERENCES

[1] M. Gerhardt, M. Ecke, M. Walz, A. Stengl, C. Beta and G. Gerisch. Actin and PIP3 waves in giant cells reveal the inherent length scale of an excited state. *J. Cell Sci.*, 127:4507–4517, 2014.

[2] M. Gerhardt, M. Walz and C. Beta. Signaling in chemotactic amoebae remains spatially confined to stimulated membrane regions. *J. Cell Sci.*, 127:5115–5125, 2014.

[3] C.A. Parent and P.N. Devreotes. A Cell's Sense of Direction. *Science*, 284:765–770, 1999.

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