Dynamics of *Physarum* microdroplets – an example for mechanochemical pattern formation in active biological matter

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Active fluids are complex fluids wherein energy is injected by active internal units. In this contribution, we consider one prominent example for an active biological fluid, namely the cytoplasm of the true slime mold *Physarum polycephalum*. The cytoplasm of *Physarum* is an active material with both viscoelastic and liquid properties. Therefore, we model the cytoskeleton as a solid matrix that together with the cytosol as interstitial fluid constitutes a poroelastic material and find different forms of mechanochemical waves [1]. To model the manifold contraction patterns observed experimentally in protoplasmic droplets of *Physarum*, we combine the poroelastic model of the cytosol with a calcium oscillator and assume that the active tension is regulated by calcium [2,3].

In two-dimensional simulations this model is shown to reproduce contraction patterns like rotating spirals, traveling waves, "turbulence" and antiphase oscillations observed experimentally in protoplasmic droplets [4,5] as well as a number of other traveling and standing wave patterns [2,3]. Examples for simulation of the calcium distribution, the height profile and the corresponding flow fields are shown in Fig. 1.

Altogether, we address deformation waves in protoplasmic droplets of the plasmodial slime mold *Physarum polycephalum* by modelling and experiments. To achieve this, we extended a model to consider the cell as a poroelastic medium, where active tension caused mechanochemical waves that were regulated by aninhibitor [1]. Our extension consists of a simple, qualitative chemical reaction-diffusion model (Brusselator) that describes the regulation of the inhibitor by another biochemical species. The biochemical reaction enhances the formation of mechanochemical waves if the reaction rates and input concentrations are near or inside an oscillatory regime. The period of the waves is found to be controlled by the characteristic oscillation period, whereas their wavelength is set by mechanical parameters [3]. The model also allows for a systematic study of the chemical activity at the onset of mechanochemical waves. We review the respective results and discuss the similarities and differences with other models and experiments on active fluids in cells.

Perspectives including the modeling of the relation of the deformation waves highlighted herein with the onset of motion of protoplasmic droplets will be discussed.

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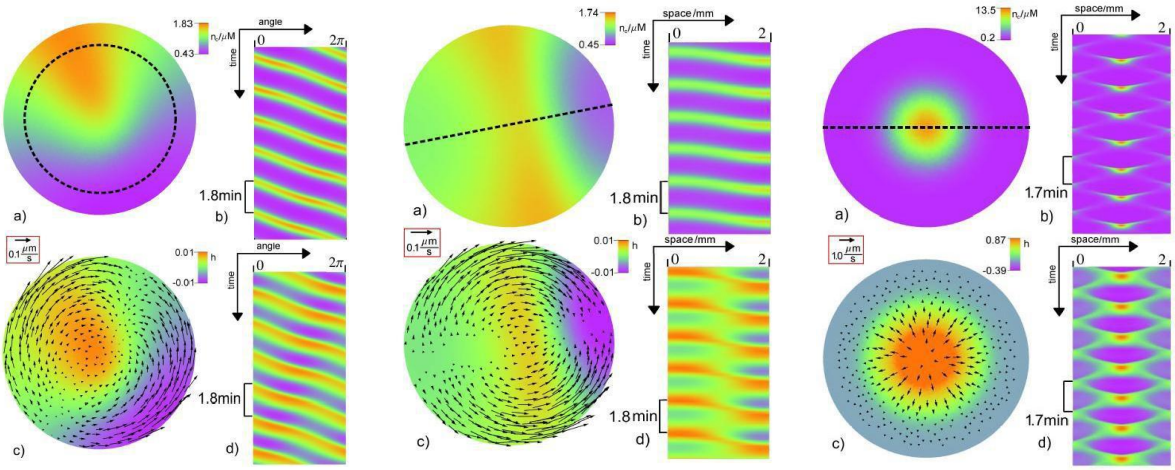

Figure 1: Examples for rotating wave (left panel), uniaxial traveling wave (middle panel) and antiphase oscillation of center and boundary simulated in the active poroelastic model for the dynamics in protoplasmic droplets of Physarum. Shown in each panel are snapshots for the calcium concentration (a), of the deformation field and flow velocities (c) as well as space-time plots along the full lines shown in the snapshot of calcium concentration (b) and deformation field (d).

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