Numerical simulation of active cell surfaces - from pattern formation to cell division

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Abstract

Shape changes of single cells are governed by the actomyosin cortex, a thin layer of active material underneath the cell surface. Besides controlling rigidity, the cortical surface exerts an active contractile tension, the strength of which being controlled by the concentration of force-generating molecules. The complex interplay of molecule transport and surface hydrodynamics gives rise to pattern formation and self-organized shape dynamics. Despite the biological importance of these phenomena, the system is far from being understood.

To improve this understanding, we present numerical simulations of such an active surface immersed in viscous fluids. The cortex is modelled as a viscoelastic surface material, described by a freely evolving Finite-Element grid. The dynamics are coupled to a surface concentration equation of force-generating molecules (e.g. actomyosin). We analyze the emerging mechanochemical patterns and shape changes and show that the activity of the surface can lead to cell division or cell migration.

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