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A computational model of self-organized shape dynamics of active surfaces in fluids

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Mechanochemical processes play a crucial role during morphogenesis, the formation of complex shapes and tissues out of a single cell. On the cellular level, the actomyosin cortex governs shape and shape changes. This thin layer of active material underneath the cell surface exerts an active contractile tension, the strength of which being controlled by the concentration of force-generating molecules. Advective transport of such molecules leads to a complex interplay of hydrodynamics and molecule concentration which gives rise to pattern formation and self-organized shape dynamics like cell division.

A minimal analytical model has been presented in two publications by Mietke et al. 2019 [1, 2]. Based on linear stability analysis, they showed that such an interplay between a concentration field – which is advected and diffuses on a spherical surface – and a flow field with a concentration-depended surface tension can lead to a ring pattern and initiates cell constriction.

In this talk, we present a novel numerical model to simulate such active surfaces immersed in fluids. We show the resulting patterning and cell shape dynamics for different parameter configurations away from the linear regime. Further, we extend the model to consider several aspects of the actomyosin cortex and discuss the changes in pattern formation and dynamics.

REFERENCES

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