M2 internship and funded PhD thesis

Interplay between flows and contractile activity in giant unicellular organism *P. Polycephalum*

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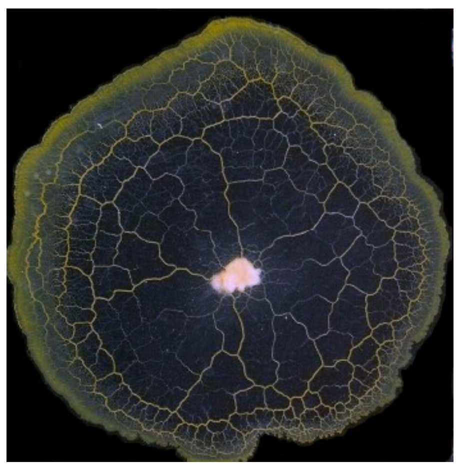
Summary

Flows over remarkably long distances are crucial to the functioning of many organisms, across all kingdoms of life. Coordinated flows are fundamental to power deformations, required for migration or development, or to spread resources and signals. A ubiquitous mechanism to generate flows, particularly prominent in animals and amoebas, is actomyosin cortex-driven mechanical deformations that pump the fluid enclosed by the cortex. Surprisingly, even in the absence of a pacemaker like a heart, cortex dynamics can self-organize to give rise to coordinated flows on vastly different scales. The aim of this project is to study the interplay between actomyosin contractile activity, fluid flows, and shaping of the organism in *Physarum Polycephalum,* a model organism intensively studied by the scientific community.

In its vegetative phase, called *plasmodium*, this organism is made of thousands of undifferentiated cells fusing in a single, multinuclear cell, and can reach macroscopic sizes (dozens of cm²). This organism then develops a tubular network in which oscillatory flows (with period ~ 1 minute) are generated by the contraction of the membranous layer surrounding the “veins”.


P. Polycephalum in its plasmodium stage.

In spite of its apparent simplicity, the growth of the tubular network shares common features with the development of vascular systems in higher organisms, or with the mechanisms that take place in the irrigation of tumors. In particular, one can clearly identify two stages in the development of the plasmodium: a growing phase during which *P. Polycephalum* explores its environment covering all the plane with a very dense and ramified tubular network. Then a reorganizing phase during which the organism seems to follow an optimization scheme: the network is less and less reticulated.

From a physicist’s perspective, the plasmodium is an **active gel** that is able, at short times, to generate and adapt contractile waves along the veins to generate peristaltic flows, and at long times to control actively its sol-gel transition to modify the network architecture.

In this project (internship and PhD), we will study how geometrical confinement affect the phase patterns of the contractile waves as well as the network development. This study should bring a better understanding of the role of hydrodynamics in the synchronization of contractile activity on short timescales, and on the network evolution of long timescales.

In practice, we will measure the thickness field of the organism using transmitted light imaging, the flow velocity field within the network using standard velocimetry techniques, and also perform calcium waves imaging with fluorescence microscopy, as calcium is known to be an activator of actin-myosin contractions. We will also study how the addition of inhibitors of contractile activity affect the network development.