INTERNSHIP PROPOSAL

Laboratory name: Physics of Cells and Cancer
CNRS identification code: UMR168
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Thesis possibility after internship: YES
Funding: NO

Self-organized flagella-like 3D chiral beating in bundles of actin filaments driven by myosin motors

The beating of the eukaryotic flagellum, e.g. of the sperm cell, is powered by around 10,000 molecular motors (dyneins) acting on a parallel array of cytoskeletal filaments (microtubules). The highly regular bending waves traveling along the flagellum arise from the coordinated modulation, in space and time, of the activity of these motors. Our group has developed a minimal molecular system in which polymerizing actin filaments in the presence of myosin motors self-assemble into beating filament bundles. The beating waveforms in this artificial system mimic those of eukaryotic flagella despite the different identity of the filaments and motors at work (Pochitaloff et al., Nat. Phys., 18:1240 (2022)). Our observations indicate that wave-like beating is a robust emergent property of motor-filament assemblies. They open an avenue (i) for a better understanding of fundamental feedback mechanisms between filament bending and motor activity depending on the motor type (currently: myosin II, V, or X) and (ii) for the bioengineering of novel motile systems.

In the original assay, beating bundles were constrained to a thin 2D layer at the surface of a coverslip. Recently, we have established that bundles can also be grown from micro-beads, revealing helical 3D beating with chiral rotations. In this internship, we propose to further develop the 3D beating bundle assay, in particular to analyze how chirality at the single-filament scale is propagated to the mesoscopic scale of a whole bundle depending on motor type and the organization of actin-filament network, and to find conditions where bundle beating may lead to persistent sperm-like swimming motion. This work will be performed in close collaboration with a 4th-year PhD student in the group.

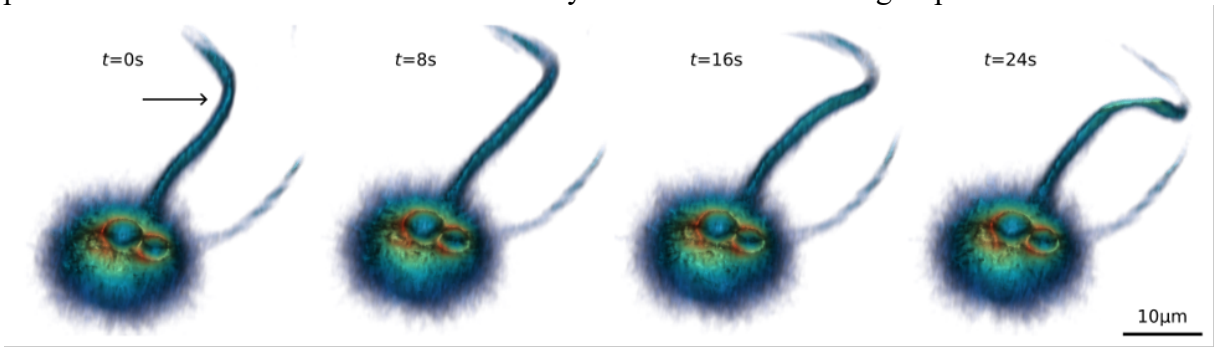

Figure 1: Actin filament bundle grown from 3-µm microbeads, exhibiting a chiral rotation.

Specialty: Soft Matter and Biological Physics
Keywords: Self-organization, spontaneous oscillations and waves, molecular motors, cytoskeleton, reconstituted systems, bottom-up approaches.
Skills: Protein biochemistry, fluorescence microscopy, data analysis.