Master *'systèmes biologiques et concepts physiques'*

INTERNSHIP PROPOSAL (2021-2022)

Where? Laboratoire Physico-Chimie Curie (CNRS UMR168 ; Institut Curie, Paris 05)
Advisor ? Pascal MARTIN (pascal.martin@curie.fr ; Tel : 01 56 24 67 48 ; webpage : link)
Thesis possibility after internship? YES (ANR funding).

TITLE: Self-Organized Flagellar-Like Beating Of Actin Bundles In Vitro

Keywords: molecular motors, biofilaments, mechano-chemical coupling, oscillations, self-organization, active soft matter.

Context: Biological systems are endowed with the remarkable ability to self-organize at large scales by orchestrating the local activity of many small constituents that each consume energy from the environment. This project focuses on the spontaneous emergence of wave-like mechanical oscillations in polar bundles of filaments, as observed in cilia and flagella of eukaryotic cells. We have recently developed a bottom-up approach based on a minimal active molecular system demonstrating in vitro that wave-like beating emerges robustly in polar filament bundles.

Experimental approach: Using surface micro-patterns to control the geometry of actin polymerization, we produce a thin network of parallel filaments. In the presence of myosin-motor dimers added in bulk, growing actin filaments self-organize into beating bundles resembling those observed in eukaryotic cilia and flagella (see Figure). A decisive asset of our assay is that the motors can be visualized using fluorescence microscopy while the actin bundle is beating, revealing that actin-bending waves are associated with myosin-density waves.

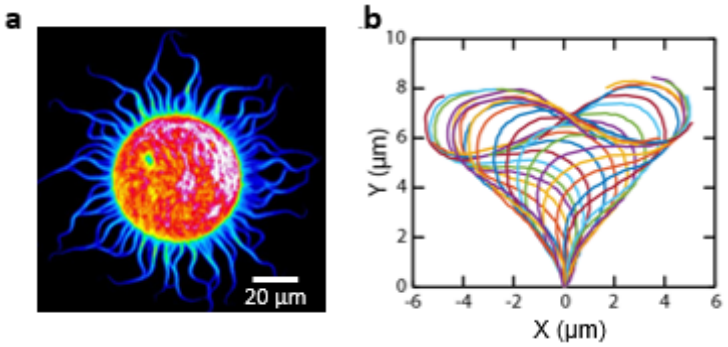

Figure: a: Bundles of actin filaments grow perpendicular to the border of a disk, where nucleation of actin polymerization is localized by protein micro-patterning (colors code for the actin density). b: Beating pattern of an actin-filament bundle resulting from automatic tracking of the bundle's movements.

Objectives: The trainee will contribute to the following tasks: (i) Study the effect on beating properties of varying the actin-bundle architecture and motor physical properties, (ii) probing the interplay between myosin-motor localization and actin-filament shape, (iii) Study the effect on beating properties of the surrounding-fluid viscosity and of an external localized force (optical tweezers), (iv) Study how a beating actin bundle interacts with its environment to generate flow, synchronize with its neighbors, and apply forces that may lead to swimming.

Environment: Our Laboratory is located at the Institut Curie (Paris), which provides an international, supportive, and inspiring environment for scientific research in a broad range of disciplines. Our project has recently been funded for 4 years by the ANR and involves a collaboration between two teams of complementary experimental expertise. Our team aims at studying beating of filament bundles at mesoscales (many filaments and motors), while the group of Guillaume Romet-Lemonne (Institut Jacques Monod, Paris) will work primarily at the molecular scale on single filaments and bundles with only a few filaments. In addition, we collaborate with theorists (Frank Jülicher, MPIKS, Dresden; Jean-François Joanny, Collège de France) to develop a physical description of our observations.

Candidate profile: We seek a highly motivated physicist or biologist interested in developing experiments at the interface between physics and biology.