M2 INTERNSHIP PROPOSAL

Laboratory name: Physics of Cells and Cancer
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Thesis possibility after internship: YES

TITLE: Self-organized 3D flagella-like beating in a minimal acto-myosin system.

SUMMARY: 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 provides a prototypical example of self-organization, in space and time, in motor-filament assemblies. Our group has recently developed a minimal molecular system in which polymerizing actin filaments in the presence of myosin motors self-assemble into beating filament bundles (Fig. 1). 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, 2022). Our observations indicate that wavelike 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. Specifically, we propose to build on our assay to develop autonomous sperm-like "micro-swimmers" by growing beating filament bundles from the surface of microbeads in solution. Our goal is to produce beating movements in 3D, analyze how the chirality at the single-filament scale translates at the mesoscopic scale of a whole bundle, and find conditions for which the beating bundles lead to persistent bead motion. This work will be performed in close collaboration with a 3rd-year PhD student in the group.

KEYWORDS: self-organization, spontaneous oscillations and waves, molecular motors and filaments from the cytoskeleton, bottom-up approaches.

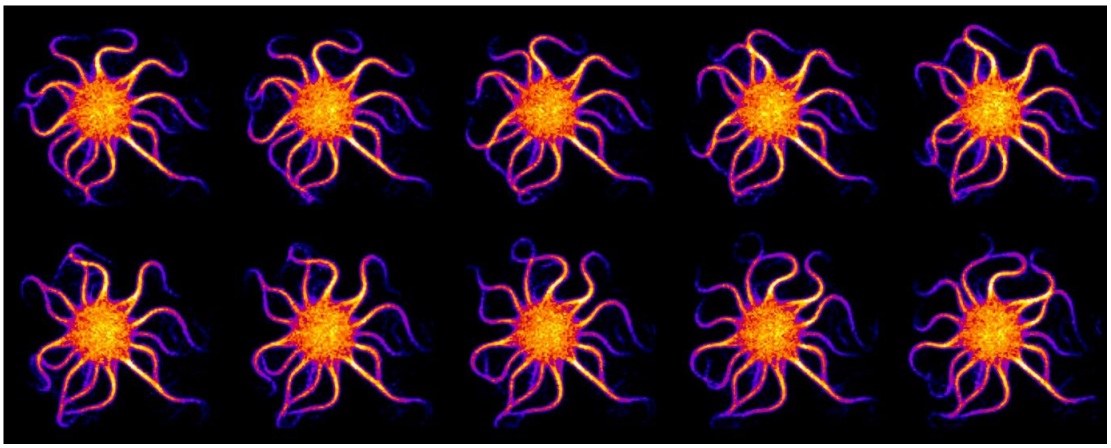

Figure 1: autonomous undulations (here in 2D) of actin-filament bundles driven by myosin-II motors.

REFERENCE:

Pochitaloff M, Miranda M, Richard M, Chaiyasitdhi A, Takagi Y, Cao W, De La Cruz EM, Sellers JR, Joanny J-F, Jülicher F, Blanchoin L, Martin P (2022) Flagella-like beating of actin bundles driven by self-organized myosin waves. Nat Phys 18:1240–1247