Internship/PhD proposal: Pneumatic cilia carpets

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Profile: Soft matter physicist or mechanical engineer with an affinity with experiments

Keywords: fluid-structure interactions, biomimetics, cilia

Context: From hairs on our skin to the microscopic cilia inside our respiratory tract, large aggregates of thin deformable structures in contact with fluids are ubiquitous. These structures can be active and beat synchronously to generate large scale flows, allowing organisms to move, feed themselves or transport key biological objects like the mucus or oocytes.

Goal: In this project, we aim at building biomimetic inflatable cilia using a low-cost fabrication method that we recently developed: bubble casting. Just like biological cilia that beats, these pneumatic hairs curl when inflated (Figure 1, left). We will first explore the miniaturization limits of the method and then study how these pneumatic cilia move when inflated in a viscous liquid both in open and channel configurations. We will try to optimize the pressure input to maximize fluid flow on a single actuator and then move to large arrays of them which can be actuated in a variety of different way (Figure 1, right).

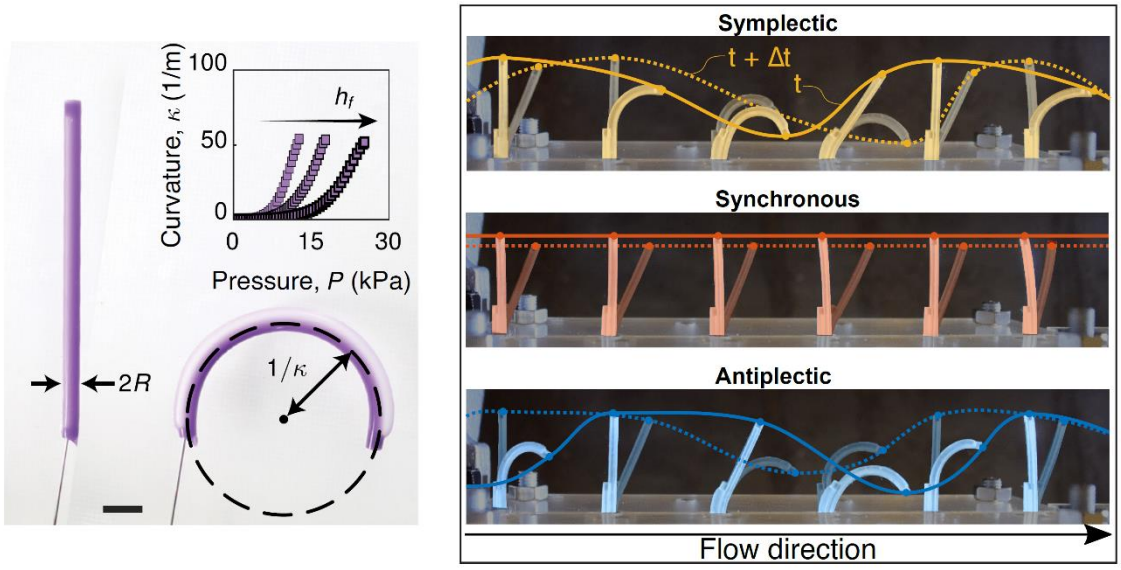

Figure 1: Left, a single cilium like bubble casted actuator. T. J. Jones, et al. Nature (2021). Right, an array of pneumatic actuator performing various metachronal wave like motions. E. Milana, et al. Science Advances (2020)

Experimental techniques: The student will build miniature pneumatic cilia using molding techniques and silicone elastomers. They will then inflate a single hair periodically in a viscous fluid and study its motion as well as the fluid motion using image analysis and particle tracking. Finally, they will build arrays of these cilia, look at collective effects and try to pump various fluids.