LadHyX Seminar – June 21, 10:45

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Biomimetic actuators in viscous fluid: designing flapping fins and beating cilia

Animals use a variety of methods to create propulsion or transport particulates and nutrition in fluids. In our research, we probe how elastic structures interact with viscous fluids to explore biomimetic approaches for fluid manipulation. In this talk, we will discuss two biomimetic systems. In the first example, we consider fish-like underwater locomotion using elastic fines. We represent fins as thin elastic plates actuated to oscillate at the leading edge and explore the effects of fin elasticity on swimming velocity and economy. We show that structural resonance yields faster swimming and that fin tapering enhances swimming economy for a wide range of actuation frequencies. We also probe the propulsion of internally actuated swimmers and show that their swimming performance benefits from passive elastic attachments at the trailing edge. In our second example, we examine the design of arrays of artificial magnetic cilia that mimic beating of natural cilia. Due to their small size, cilia operate in a low Reynolds number environment, where a non-reciprocal beating is required to produce a net fluid flow. Our artificial cilia are formed from thin ferromagnetic films and are actuated by a rotating permanent magnet. We show how arrays of such magnetic cilia can be designed to beat in metachronal wave fashion. We also show how magnetic cilia can be individually immobilized by integrating electrostatic actuation to enable individual control of cilia beating.