Internship/PhD proposal

Understanding and modelling the locomotion of diatom chains

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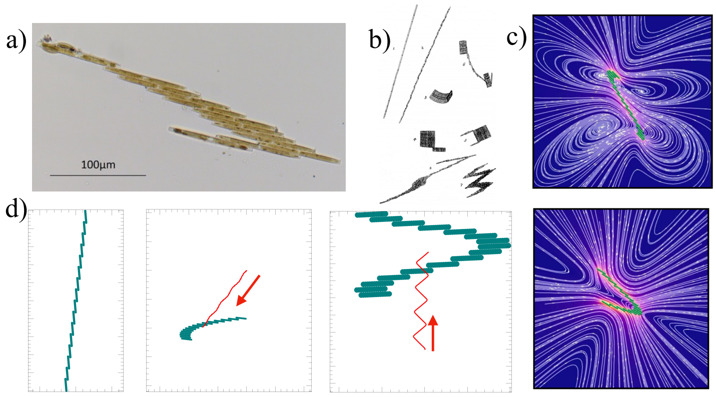
Start date: anytime from Feb. 2024

Context: Diatom chains are cohesive assemblies of unicellular microorganisms that are found in still and fresh waters. Some species move passively with the ambient flow while others use various strategies to move or self-propel. One species in particular, called *Bacillaria Paxillifer,* forms colonies of stacked rectangular cells that slide along each other while remaining parallel. Their intriguing coordinated motion leads to beautiful and nontrivial trajectories at the scale of the colony [1]. So far, little is known about the sliding mechanisms, the purpose of these movements, their mechnical efficiency and the underlying (fluid) mechanics.

A numerical method has been developed at LadHyX to efficiently simulate this kind of systems and the flow field they generate [2]. Our tool is used to model *Bacillaria Paxillifer* as an assembly of rigid rods that are constrained to remain parallel relative to each other with a prescribed sliding motion. Our preliminary studies have shown that the direction and the swimming speed of such micro-organisms change non-monotonically with the sliding delay between pairs of cells.



a) Microscope view of B. Paxillifer. b) Various cooordinated motions of a colony observed under a microscope [1]. c) Simulated flow fields around two colonies with different conformations. d) Simulated trajectories of a colony with increasing sliding phase shift between cells (left to right) [2].

Cell cultures and preliminary microfluidic experiments have also been carried out in the lab, in collaboration with G. Amselem (Prof. Ecole Polytechnique), to characterize the motion of the colonies and the flow field they generate. A post-processing tool has been written to extract the sliding motion between cells from experiments in order to prescribe them in simulations.

Goals: The goal of this project is to reproduce and understand the mechanisms behind the locomotion of the colony. The intern will use our numerical tool, and collaborate with experimentalists, to characterize the sliding mechanisms between cells and explore the various locomotion modes of the colonies. He/she will search for optimal locomotion modes in terms of mechanical efficiency and compare them with experimental observations. At longer term, he/she will use modern AI techniques, such as reinforcement learning, to find the optimal strategies to perform a specific task, such as reaching a target location.

Profile: Candidates must have a taste for numerical modeling, basic knowledge of Python, with good training in fluid mechanics or soft matter.

Environment: LadHyX is a world-renowned laboratory in fluid mechanics and interdisciplinary research at Ecole Polytechnique, near Paris. The intern/future doctoral student will benefit from interactions with experimentalists from Prof. Amselem's group at LadHyX.

Contact: please send a CV, cover letter, and the name and email address of at least one reference to blaise.delmotte@ladhyx.polytechnique.fr.

[1] Kapinga, M. R., & Gordon, R. (1992) *Diatom research*.
[2] Usabiaga, F. B., & Delmotte, B. (2022) *Journal of Computational Physics*. "A numerical method for suspensions of articulated bodies in viscous flows"