Internship (L3/M1/Césure)

Sedimentation of diatom chain colonies

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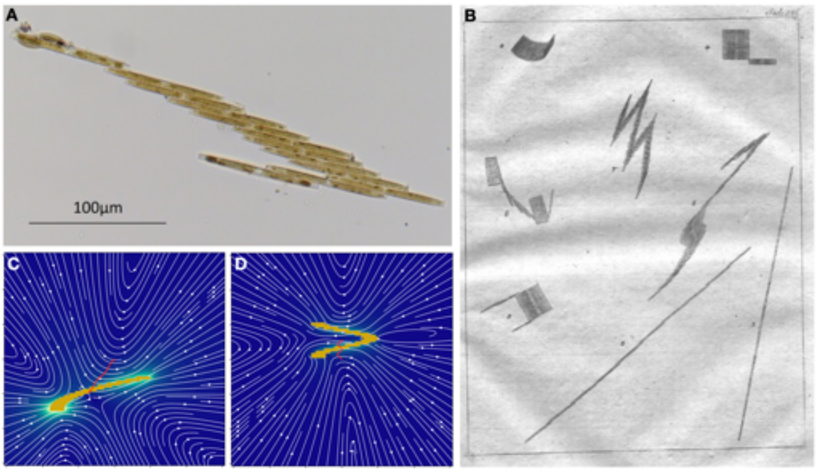
Start date: anytime from Jan. 2025
Host Lab: LadHyX

Context: Diatom chains are cohesive assemblies of unicellular microorganisms that are found in still and fresh waters. Some species are passively transported by ambient currents and settle due to the weight of their dense silica shells, while others have 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. As observed in experiments, and reproduced by our numerical model, their intriguing coordinated motion, leads to beautiful and nontrivial trajectories at the scale of the colony [1]. However, the effect of gravity and external flows on the dynamics of diatom chains must be investigated to understand the behavior of plankton and marine snow aggregates as they sink, and capture CO2, to the ocean depths [3].

A numerical method has been developed at LadHyX to efficiently simulate these microorganisms 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.



A) Microscope view of B. Paxillifer. B) Various cooordinated motions of a colony observed under a microscope [1]. C-D) Simulated flow fields around two colonies with different conformations.

Goals: The goal of this internship is to investigate the impact of colony geometry (such as cell aspect ratio and colony size) and sliding motion on their sedimenting trajectories. The variability in drag experienced by deforming colonies, combined with recent findings on the sedimentation of rigid complex-shaped objects at low Reynolds numbers [4, 5], suggests the potential for intricate non-trivial trajectories. In parallel, their transport in simple background flows (such as shear flows, Taylor-Green vortices,…) will be investigated.

Profile: Candidates must have a taste for numerical simulations and a basic knowledge of Python.

Environment: LadHyX is a world-renowned laboratory in fluid mechanics and interdisciplinary research at Ecole Polytechnique, near Paris. The intern student will collaborate with Julien Le Dreff, PhD student on this project.

Contact: please send a CV to blaise.delmotte@polytechnique.edu and julien.le-dreff@polytechnique.edu.

References:

[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.

[3] Chajwa R. et al (2024) *Science*. Hidden comet tails of marine snow impede ocean-based carbon sequestration.

[4] Miara T. et al (2024) *Communications physics*. Dynamics of inertialess sedimentation of a rigid U-shaped disk.

[5] Huseby E. et al (2024) *Arxiv*. Helical Ribbons: Simple Chiral Sedimentation.