Internship (M1/Césure/M2)

Sedimentation of diatom chain colonies in complex flows

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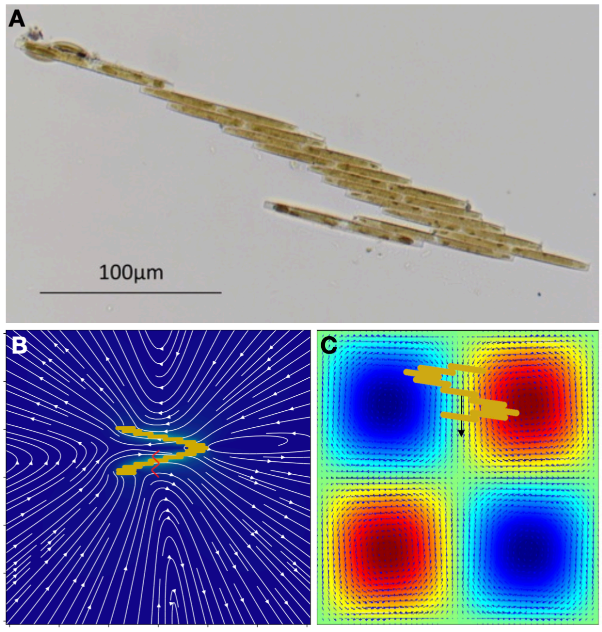
Start date: anytime from Jan. 2026
Host Lab: LadHyX

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 (see Fig. A). 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], see Fig. B. However, the effect of gravity and externat ambient 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 CO_2, 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) Simulated swimming trajectory (in red) and flow field around one B. Paxillifer colony. C) Sketch of sedimentation in Taylor-Green Vortices

Goals: The aim of this internship is to investigate how diatom chain colonies sediment and are transported within complex flows, such as Taylor–Green Vortices (TGV). TGV are often used as a simplified model of turbulence, allowing the study of particle dynamics in coherent vortical structures. Diatom chains are found in oceans, estuaries, and rivers, where the smallest turbulent structures (at the Kolmogorov scale) can be either larger or smaller than the colonies themselves. The velocity of these vortices (which also depends on the environment), the cell aspect ratio, and colony activity are additional key parameters. In this project, we will examine which factors control sedimentation or aggregation within vortices. Extensions to turbulent flows will then allow us to pursue the study in more realistic conditions

Profile: Candidates must have a taste for numerical modeling, basic knowledge of Python.

Environment: LadHyX is a 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, cover letter, and the name and email address of at least one reference 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.