Internship/PhD proposal

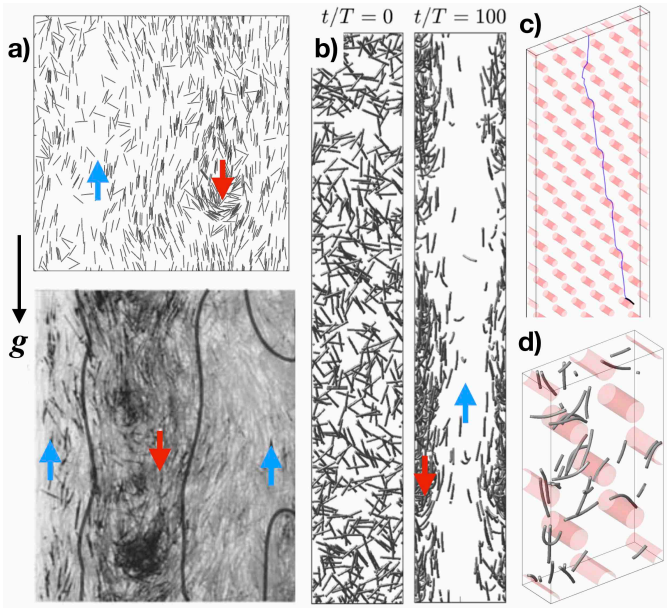
Collective sedimentation of flexible fibers in structured media

Supervisor: Blaise Delmotte (LadHyX, Ecole Polytechnique), blaise.delmotte@ladhyx.polytechnique.fr
Co-supervisor: Eric Keaveny (Dept. Maths, Imperial College London), e.keaveny@imperial.ac.uk

Start date: anytime from Feb. 2024
Host lab: LadHyX

Context: The sedimentation of small flexible and rigid fibers in structured media embedded with obstacles finds many occurrences in natural and industrial processes, such as the motion textile fibers in wastewater treatment units, wood pulp fibers in the papermaking process or the sinking of microplastics and plankton in the ocean.

In the rigid case, theoretical and experimental studies have shown that collective sedimentation in a clear fluid leads to the formation of dense clusters of particles with high speeds, called streamers, coexisting with regions of backward flows [1,2] (Fig. 1a). Surprisingly, the effect fiber flexibility on this instability and the resulting streamers has received much less attention so far [1] (Fig. 1b). When adding obstacles, the motion of a single fiber can drastically differ from its dynamics in clear fluids [4]. Our first experiments and simulations have shown that obstacles can deviate the fibers, trap them or guide them along preferred directions that depend on the fiber deformability, length and obstacle arrangement [4,5]. These results open promising perspectives for fiber sorting applications based on their length or deformability. But, to the best of our knowledge, and despite its relevance to fundamental and applied research, the collective sedimentation of fibers in structured media has never been investigated.



a) Sedimentation of rigid fibers. Top: simulations [3]. Bottom: Experiments [2]. Red arrows: downward motion, Blue arrows: upward motion. a) 3D simulation of the sedimentation of flexible fibers [4]. c) Lateral motion of a single fiber settling in a structured medium [4]. d) Multiple fibers in a lattice of obstacles (preliminary simulations).

Goals: The aim of this project is to investigate the collective sedimentation of rigid and flexible fibers in structured media embedded with obstacles using numerical simulations. The intern will use the numerical tools developed by the supervisors' groups. She/he will first study the collective sedimentation of flexible fibers in clear fluids to understand the effect of flexibility on the instability and the formation of clusters. She/he will then add obstacles to see how this instability is affected by their presence.

Profile: Candidates must have a taste for numerical modeling, programming in Python and/or C, 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 other colleagues at LadHyX, in addition to regular visits at Imperial College London to work with the co-supervisor Prof. Eric Keaveny.

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

References

[1] Du Roure, O., Lindner, A., Nazockdast, E. N., & Shelley, M. J. (2019). *Annual Review of Fluid Mechanics*
[2] Metzger, Butler & Guazzelli. (2007). *Journal of Fluid Mechanics*
[3] Schoeller, Townsend, Westwood, & Keaveny (2021). *Journal of Computational Physics*
[4] Makanga (2023). Transport and deformation of flexible fibers in structured environments. *PhD thesis*
[5] Makanga, U., Sepahi, M., Duprat, C., & Delmotte, B. (2023). *Physical Review Fluids*