M1 or M2 Internship: Propelling objects using swimming microorganisms

Gabriel Amselem, LadHyX, Ecole Polytechnique
gabriel.amselem@polytechnique.edu
Mojtaba Jarrahi, FAST, Université Paris-Saclay
mojtaba.jarrahi@universite-paris-saclay.fr

Active particles such as the swimming microalgae *Chlamydomonas reinhardtii* are inherently out-of-equilibrium systems, able to uptake energy from their environment and convert it to motion [1]. These systems are widespread in the biological world, from cellular Brownian motors such as kinesin and myosin, to swimming microorganisms such as bacteria and microalgae [2]. Over the past decade, artificial active particles have also been developed, where particle motion results from the engineered asymmetry of the particle combined to its interaction with the surrounding fluid [3].

The aim of this internship is to make use of the swimming microalga *C. reinhardtii*, a microorganism of size ≈ 10 μm, to propel objects that are larger than itself. These objects can be hard beads or liquid droplets, see Fig. 1. The microalgae are phototactic (they can move towards or away from a light source), and the hope is to be able to use light to drive the objects in a controllable direction. In addition to the fundamental questions in hydrodynamics and biophysics that the project tackles, the results of the work have vast potential applications ranging from targeted delivery of drugs for healthcare purposes [4] to the depollution of soils and new harvesting techniques [5].

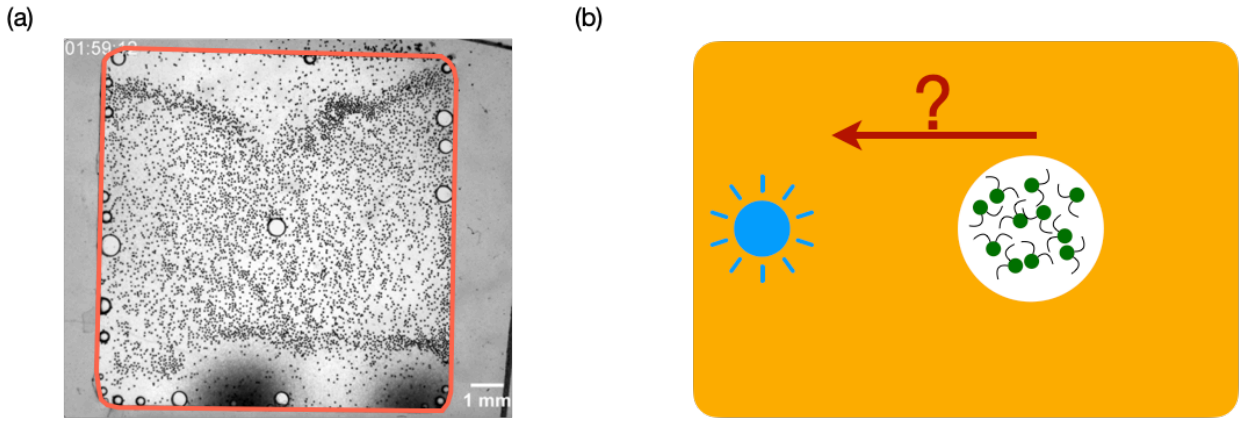

Figure 1: (a) Beads of diameter 50 μm (black dots) have been depleted from the boundaries of a square well (highlighted in red), thanks to the motion of algae (too small to be visible on the image). (b) Potential experiment: algae are encapsulated in a large water droplet (white), suspended in oil (yellow). A light stimulus is applied. Can this drive a motion of the droplet?

The project is a part of a collaboration between the FAST (Université Paris-Saclay) and LadHyX (Ecole Polytechnique). The selected candidate will benefit from the expertise in microfluidics and hydrodynamics of *C. reinhardtii* developed in our teams [5]. The internship is primarily experimental, with a lot of quantitative image and data analysis. The internship can be followed by a PhD thesis depending on the candidate.

References

[1] C. Bechinger, R. Di Leonardo, H. Löwen, C. Reichhardt, G. Volpe, and G. Volpe. *Reviews of Modern Physics*, 88(4):045006, 2016
[2] E. Lauga and T. R. Powers. *Reports on progress in physics*, 72(9):096601, 2009
[3] S. Sánchez, L. Soler, and J. Katuri. *Angewandte Chemie International Edition*, 54(5):1414, 2015
[4] J. Li, B. de Avila, W. Gao, L. Zhang, and J. Wang. *Robot*, 2(4):1, 2017
[5] C. N. Minh, H. Peerhossaini, and M. Jarrahi. *Biomicrofluidics*, 16(5):054103, 2022