Internship: Propelling objects using swimming microorganisms

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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]. When passive particles are immersed in an active bath of micro-swimmers, they may be displaced due to the activity of the suspension. This enhanced motion can lead to rich phenomena, such as aggregation or phase separation [2–4].

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. In preliminary experiments, we enclosed a suspension of algae and beads in a well. When a high intensity light was shined on one side of the well, the algae performed negative phototaxis and swam away from the light, eventually accumulating at the opposite well boundary. As their local concentration grew, the algae pushed away the passive beads (Fig. 1a). We now want to understand how the beads are displaced to eventually be able control the final spatial distribution of beads. Other preliminary experiments consist in enclosing algae in droplets, see Fig. 1b. We want to know if the droplet can move thanks to the swimming of the algae.

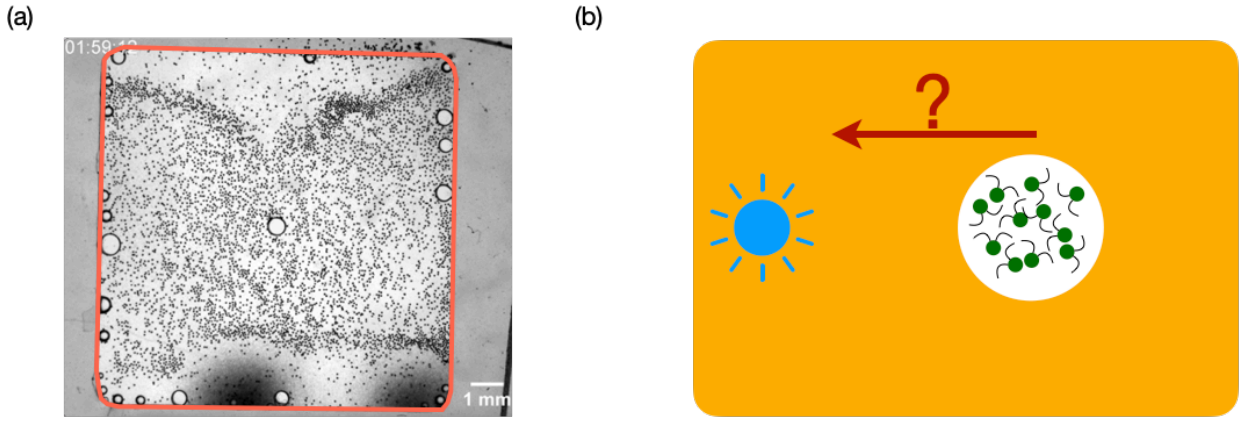

Figure 1: (a) Beads of diameter 50 μm (black dots) have been depleted from the boundaries of a square well (highlighted in red), thanks to the motion of algae (accumulated in the bottom dark regions of size ≈ 1 mm). (b) Potential experiment: algae are encapsulated in a large water droplet (white), suspended 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 LadHyX (Ecole Polytechnique) and the FAST (Université Paris-Saclay). 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] J. Stenhammar, R. Wittkowski, D. Marenduzzo, and M. E. Cates. *Physical review letters*, 114(1):018301, 2015
[3] J. Bouvard, F. Moisy, and H. Auradou. *Physical Review E*, 107(4):044607, 2023
[4] D. R. Rodriguez, F. Alarcon, R. Martinez, J. Ramírez, and C. Valeriani. *Soft Matter*, 16(5):1162, 2020