M2 internship: Transport in 2D by microswimmers

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Subject

One of the most basic needs of any living organism is to find enough nutrient in its environment to survive. Swimming microorganisms inhabit a wide diversity of environments, from oceans to soil to animal hosts, and their ability to move is crucial when foraging for food. Yet, the flows created by these swimming microorganisms can also serve a major role in enhancing an organism's nutrient uptake by mixing the surrounding medium, and allowing food particles to reach the cell faster than by pure diffusion. In particular, collective behaviors in dense suspensions of microorganisms such as algae can induce the formation of coherent structures or complex flow patterns, which may lead to enhanced mixing. The fundamental understanding of the mechanisms underlying this enhanced transport could provide insight into natural processes of nutrient uptake, and pave the way for the design of artificial biomimetic micro-mixers.

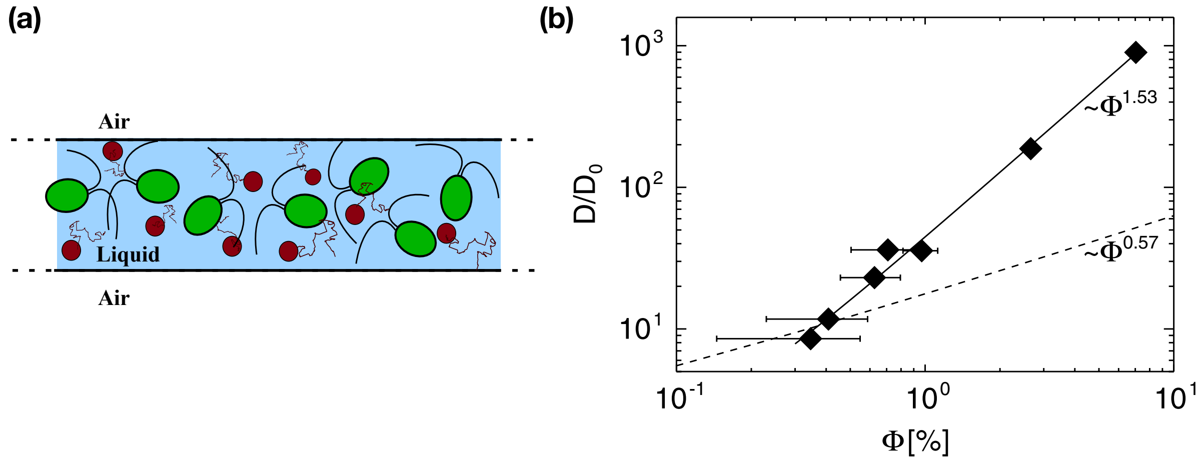

Figure 1: (a) Sketch of the experimental setup: a thin film contains a suspension of algae (purple) and passive tracers (black), used to quantify mixing. (b)The experimental effective diffusion coefficient in a dense suspension of algae, as a function of the volume fraction of algae. Experimental points (diamonds) cannot be explained by the current theory (dashed line) [1].

Recent experimental results have shown that, under confinement in thin films, particle transport by microorganisms is enhanced compared to freely moving swimmers (see Fig. 1) [1]. However the physical origin of these results has not been explained and remains to be understood. The goal of this internship is to combine experiments and simulation to study the effect of confinement on particle transport in active suspensions. Microfluidic experiments will be designed to measure the effective diffusion coefficient of passive tracers in a suspension of algae under different experimental conditions, varying the degree of confinement as well as the boundary conditions (slip or no-slip) at the interface. Simulations will be carried out in parallel by another student in the lab next door under the supervision of Blaise Delmotte.

References

[1] H. Kurtuldu, J. S. Guasto, K. A. Johnson, and J. P. Gollub, *Proc. Natl. Acad. Sci.* **108**, 10391 (2011)