MARANGONI PROPULSION AND INTERACTION WITH FLOWS

LABORATORY : Institut Lumière Matière

LEVEL : M2
TEAM(S) : LIQ@INT

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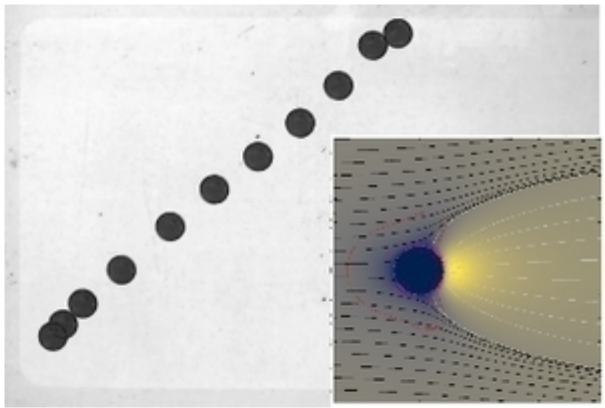
KEYWORD(S) : soft matter / fluid mechanics / statistical physics

SCIENTIFIC CONTEXT :

The presence of surfactant such as amphiphilic molecules at the air-water interface may locally alter the surface tension and induce a flow in the underlying water, as exemplified in the celebrated tears of wine phenomenon. Such Marangoni effects have a long history - with early observation dating back to 1557- but their study has received a new impetus with the current interest in active matter. Indeed, they can be exploited to design "Marangoni swimmers": macroscopic particles without moving parts that spontaneously self-propel at the surface of water (Figure). Such swimmers have been developed in our team [1] where their behavior was shown to motivate a host of questions, from their individual propulsion to striking collective properties such as active turbulence [2].



Top view of a Marangoni swimmer in a pool. Inset: simulated flow.

MISSIONS :

Having recently characterized the propulsion mechanism at an individual scale and in the presence of a simple external flow, the goal is now to study the interactions between two swimmers. To do so, we will leverage the techniques we have developed for characterizing both the flows and forces, using PIV (Particle Image Velocimetry) and a cantilever force sensor. We will examine the forces and flows that develop around a pair of swimmers. We will also investigate the interactions of a swimmers with a wall.

In the long term, we will seek to understand how the transport of an interfacial swimmer is affected by a complex external flow. By placing a swimmer in a vortex network, we will study, both experimentally and numerically, the interaction between the swimmer and the flow on the scale of a vortex. This study will also unveil the resulting large-scale transport properties of the swimmer, a complex situation that involves many couplings.
The student will combine experimental investigation with exploration of simplified models to develop a clear physical understanding. This topic lies at the confluence of soft matter, fluid mechanics and statistical physics.

OUTLOOKS :

Opening toward a PhD: yes (funding with «bourse ministère»).

BIBLIOGRAPHY :

[1] Self-propulsion of symmetric chemically active particles: Point-source model and experiments on camphor disks. Boniface, Cottin-Bizonne, Kervil, Ybert and Detcheverry, *Physical Review E* (2019).

[2] Kolmogorovian active turbulence of a sparse assembly of interacting Marangoni surfers. Bourgoin, Kervil, Cottin-Bizonne, Raynal, Volk and Ybert, *Physical Review X* (2019).

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