INTERACTIONS OF MARANGONI SWIMMERS/SURFERS

LABORATORY : Institut Lumière Matière
IN COOPERATION WITH : iLM

LEVEL : M2
TEAM(S) : LIQ@INT

Direction

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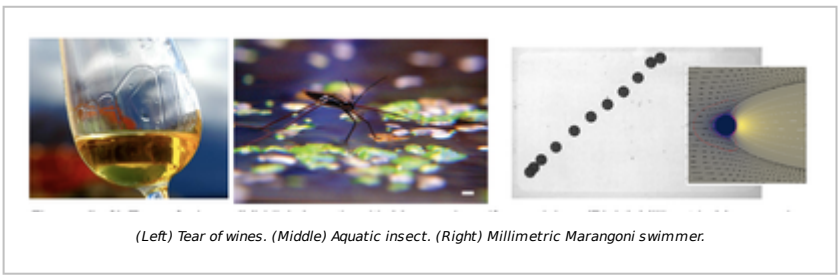
KEYWORD(S) : active matter / soft matter / Interfacial swimmer

SCIENTIFIC CONTEXT :



(Left) Tear of wines. (Middle) Aquatic insect. (Right) Millimetric Marangoni swimmer.

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” effect (Figure left). The study of such Marangoni effects, dating back to the 16th century, has received a new impetus with the current interest in active matter. Some millimetric aquatic insects, like Velia and Microvelia, exploit this effect to self-propel by releasing chemicals that create surface tension differences ((Figure middle). A similar principle is currently exploited to create artificial “Marangoni swimmers”: particles that move autonomously at the water surface without moving parts (Figure right). Such swimmers have been developed in our team [1]. Their behavior raises intriguing questions about individual propulsion and collective dynamics like active turbulence [2].

MISSIONS :

The goal of this internship/PhD project will focus on the interactions between Marangoni swimmers. The student will use advanced techniques such as PIV (Particle Image Velocimetry) and cantilever force sensors. We will also study the effects of complex flows, such as arrays of vortices, on the swimmer trajectories. The student will combine experimental investigation with exploration of simplified models to develop a clear physical understanding. This topic lies at the crossroads of soft matter, fluid mechanics and statistical physics.

OUTLOOKS :

The long-term ambition is to unveil the resulting large-scale transport properties.

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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