M2 Research internship/ PhD

Interactions of Marangoni swimmers/surfers

Where : Institut Lumière Matière, Lyon, team Liquides et Interfaces, UMR 5306
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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].

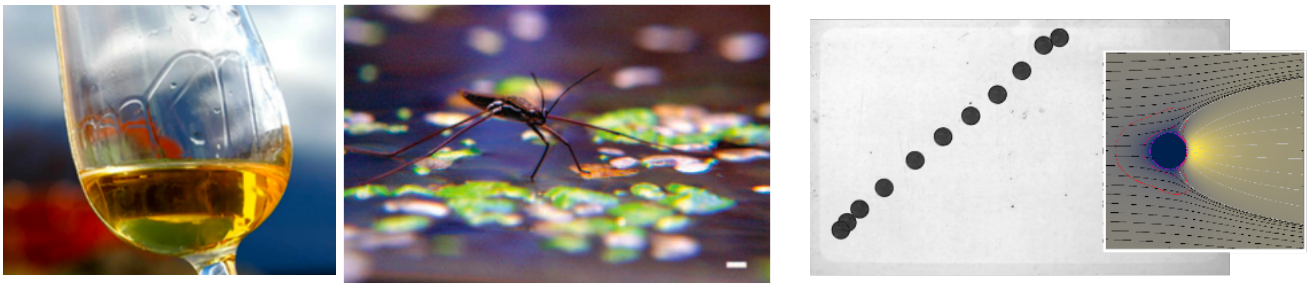

Figure: (Left) Tear of wine. (Middle) Aquatic insect with Marangoni self-propulsion. (Right) Millimetric Marangoni swimmer in a pool. Inset: simulated flow.

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

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

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References

[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).