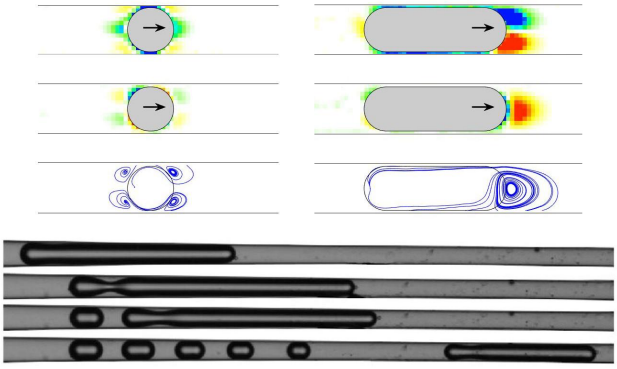
Master 2: ***Parcours Systèmes complexes***

INTERNSHIP PROPOSAL **: Self-propelled droplets facing adversity**

Laboratory name: Gulliver
CNRS identification code: UMR 7083
Internship director'surname: Mathilde Reyssat
e-mail: mathilde.reyssat@espci.fr
Phone number: 01 40 79 51 61
Web page: https://www.ec2m.espci.fr
Internship location: ESPCI Paris - 10 rue Vauquelin, 75005 Paris

Thesis possibility after internship: YES
Funding: No

Artificial micro-swimmers have recently become a central field of research in soft-matter, the reason being that they open the way towards numerous applications at small scales, including fluid pumping, sensing and capture of molecular species, transport and cargo delivery.
A very promising and original type of swimmer developed in our team, consists in pure water droplet swimming in an oil phase containing micelles of surfactant. The swimming mechanism and motion of these droplets have been investigated in details in the past few years [1]. We have recently studied the swimming behavior of such micro-droplets in confined conditions in capillary tubes. We have observed non-conventional spontaneous fragmentations under extreme confinement that we have related to the interfacial activity of the system [2].



PIV analysis around swimming droplets in a capillary tube. Under extreme confinement, spontaneous fragmentations are observed.

We are now interested in studying how the swimming velocity of the droplets depends on the shear stresses at their interface and how we can modify it. Preliminary studies in the lab have shown that the velocity of the droplets seems to increase when the droplets face a counterflow. The first goal of this project is to investigate in details this unexpected swimming behavior. Microfluidics is a promising platform to control accurately the swimming environment of such droplets. We will take advantage of this tool to investigate how the geometrical and physico-chemical conditions can control the velocity and trajectories of such self-propelled droplets. This experimental aspect of this work will be done in the Gulliver lab at ESPCI. Theoretical developments could be in collaboration with Ramin Golestaninan in the Max Planck Institute in Gottingen.

We are looking for a highly motivated student, with a good background in soft matter physics. Important concepts to be at ease with are surface tension and hydrodynamics. Experimental skill in microfluidics and ease with image analysis is an advantage, but is not mandatory.

[1] Z. Izri *et al.*, Self-Propulsion of Pure Water Droplets by Spontaneous Marangoni-Stress-Driven Motion, *PRL* **113**, 248302 (2014).
[2] C. de Blois *et al.*, Swimming droplets in 1D geometries: an active Bretherton problem, *Soft Matter*,**17**, 6646 (2021).

Keywords: interfacial activity, microfluidics.