STAGE DE M2 / THÈSE - année 2020-2021

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Active trapping of microswimmers confined in a foam channel

How do micro-organisms (bacteria, microalgae, worms, etc.) move in confined environments? This is relevant in natural conditions where micro-organisms have to move in overcrowded and complex environments such as porous media (soils, sediments, aquatic foams). Inspired by the consequences of marine foams (Fig. 1a) on planktonic ecosystems, recent experiments in our group have shown that liquid foams act as a filter, retaining motile planktonic cells, while non-motile cells can flow through the foam [1].

A liquid foam consists of interconnected internal liquid channels (Fig. 1c) [2]. Microscopic 2D observation of microswimmers in concave triangular chambers mimicking the cross-sectional shape of the channels of a foam revealed that the microswimmers accumulate in the corners (Fig. 1d). In 3D channels, however, the cells are subject to two additional effects: gravity and liquid flow. Since the algae are likely to orient themselves in the gravity field, it is expected that these two effects will interact with the swimming movement of the algae (Fig. 1e). Do the micro-algae accumulate in the sharp edges of the channel? subject to gravity, do they tend to swim upwards? what is the effect of shear and flow velocity on their trajectory?

During this internship, we will try to answer these questions by developing a 3D tracking experiment. The biflagellate alga *Chlamydomonas rheinardtii* (CR - Fig. 1b) will be placed in a rigid channel having sharp edges. While the emphasis will be on setting up and carrying out experiments, the data will be analyzed and interpreted in the context of the hydrodynamics and the transport of self-propelled microorganisms in a confined environment in which the flow is dominated by the geometry of the channel.

This internship may be followed by a PhD thesis guided by the general theme of plankton retention in aquatic foams.

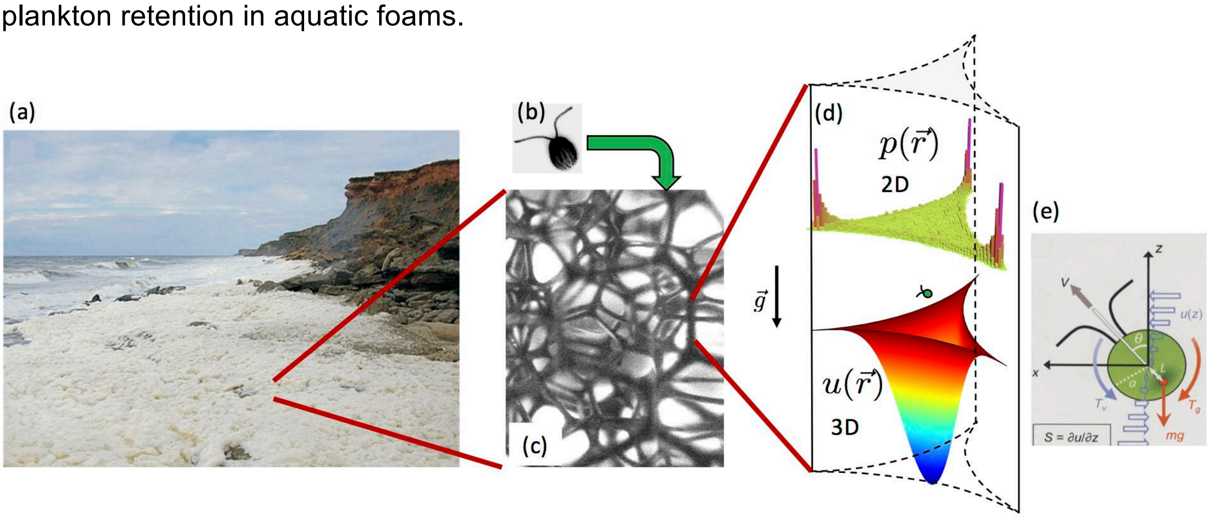

Figure 1: (a) Sea foam in the eastern English Channel; (b) Micro-alga Chlamydomonas reinhardtii (CR - body diameter : 5 to 10 μm); (c) internal structure of the liquid foam, made of interconnected liquid channels (in black); (d) how does the cell probability density function $p(\vec{r})$ in 2D) interact with the Poiseuille flow $u(\vec{r})$ in 3D) and the gravity field in a liquid flow channel? (e) possible orientation of a CR cell in a shear flow under gravity.

[1] Roveillo Q, Dervaux J, Wang Y, Rouyer F, Zanchi D, Seuront L & Elias F, *Trapping of swimming microalgae in foam*, J. R. Soc. Interface 17 : 20200077 (2020). http://dx.doi.org/10.1098/rsif.2020.0077
[2] I. Cantat, S. Cohen-Addad, F. Elias, F. Graner, R. Höhler, O. Pitois, F. Rouyer, A. Saint-Jalmes, "*Les Mousses. Structure et Dynamique*", Coll. Echelles, Ed. Belin, 2010.
"*Foams. Structure and Dynamics*", trad. R. Flaman, Ed. S. Cox, Oxford University Press, 2013.