INTERNSHIP PROPOSAL

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Active trapping of microswimmers confined in a foam channel

A massive formation of stable sea foam is regularly observed on certain shores (Fig. 1a). The foam stability is in general the result of a phyoplankton bloom. The consequences for the local marine ecosystem are dramatic: a 5-fold decrease in the phytoplankton biomass is observed in the water column. Our hypothesis is that a relevant part of the phytoplankton, advected in the foam during the foam formation, remains trapped in the interconnected network of internal liquid channels within the foam (Fig. 1c). Among phytoplanktonic organisms, many are flagellated and therefore motile.

We have recently shown that liquid foams act as a filter, retaining motile planktonic cells, while non-motile cells can flow through the foam [1]. Our aim is to shed light on those results by observing locally the motion of microswimmers inside the foam channel. Microscopic 2D observation of microswimmers in concave triangular chambers have 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 (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. The microswimmer trajectory will be measured, 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.

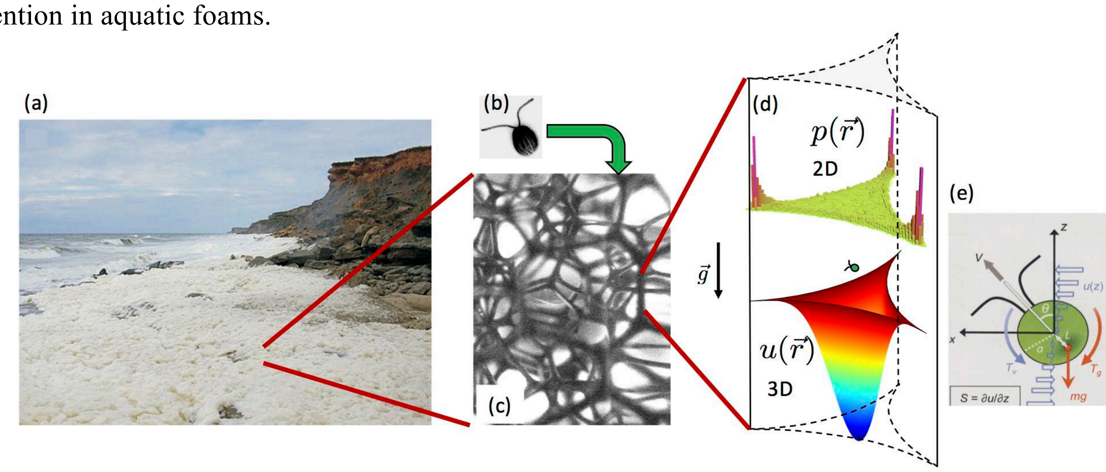

Figure 1: (a) Sea foam in the eastern English Channel; (b) Micro-alga Chlamydomonas reinhardtii *(CR - body diameter: 5 to 10 µm); (c) internal structure of the liquid foam, made of interconnected liquid channels (in black); (d) how does the cell probability density function $p(\vec{r})$ in 2D) interact 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, "Foams. Structure and Dynamics", trad. R. Flaman, Ed. S. Cox, Oxford University Press, 2013.