M2 internship proposal:
Impact of bacterial motility on the accumulation of biosurfactants at air-water interfaces

Institut de Physique de Rennes (UMR 6251), Université de Rennes (Brittany, France)

Supervisors : François Peaudecerf & Nathan Chapelle
Duration : **5 to 6 months**, with PhD possibility after internship (funded)

Context

Evaporation from bare soils is a key hydrological process which returns a fifth of terrestrial precipitations directly to the atmosphere. This macroscopic phenomenon is governed at the microscale by **capillary flows** along water films between the top of the soil and the water at depth. The stability of these films is crucial to efficient drying and is highly **sensitive to the physico-chemistry** of the soil such as the **surface tension** at air-water interfaces or the **contact angle** of the aqueous phase with grains [1].
In soil, bacteria abound, with $\sim 10^{10}$ bacteria per gram of top soil. Many of them release surface active components – surfactants – in their surroundings which can strongly decrease the surface tension at air-water interfaces (Figure 1) and change the contact angle [2]. To date, however, little is known about the potential impact of these bacteria on drying dynamics. **How do surfactants accumulate at drying interfaces? Does bacterial behavior, in particular motility by swimming, modify the dynamics of this accumulation? What are the resulting consequences for the dynamics of these interfaces inside the soil pores?**

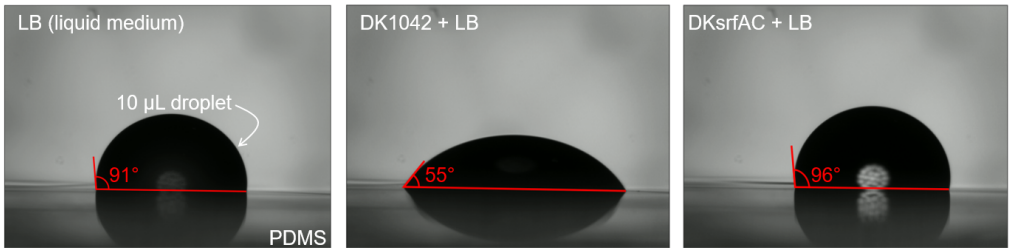

Figure 1: Measurements of contact angles between a hydrophobic substrate (PDMS) and a 10 µL droplet of filtered bacterial culture after growth. The contact angle measured with a wild type *B.subtilis* strain which releases surfactants (photograph in the middle) is strongly reduced compared to the contact angle measured with the liquid medium (photograph on the left) or with a *B.subtilis* strain which cannot produce surfactants (photograph on the right).

References

[1] D. Or et al., "Advances in Soil Evaporation Physics - A Review", Vadose Zone Journal, 2013

[2] J Q Yang et al., "Evidence for biosurfactant-induced flow in corners and bacterial spreading in unsaturated porous media", PNAS, 2021

Internship objectives

We started investigating these questions at the level of the single pore with the PhD project of Nathan Chapelle. We have already started developing an original experimental setup to follow the deformation of a single air-water interface which is put under evaporative forcing in the presence of surfactants, and validated our choice of model bacterium, *B.subtilis*. The goal of this internship is to get familiar with this setup and to shed light on the role of **different bacteria phenotypes** (in particular motile vs non-motile) on the **repartition of bacteria and surfactants in the bulk and at this air-water interface**. To do so, the intern will use **microfluidic chips** to mimic single pores of the soil, with an air-water interface present. Using optical microscopy techniques, the intern will **track individual bacteria** and characterize their behavior during evaporation from the interface. These results will be linked to changes in interfacial dynamics.

Candidate profile

We are looking for a highly motivated student with a keen interest in **interdisciplinary research combining biology and physics**, for this mostly **experimental internship** but with accompanying modelling aspects which could also be explored. The internship candidate should have a background in **biophysics, physics of complex and soft matter, mechanical or chemical engineering, or microbiology with solid physics knowledge.**

Practical details and how to apply

- This 5-to-6-month internship should start on **February 2025** but the starting date is flexible.
- The trainee will be trained in **microfabrication by soft photolithography, image processing** as well as **fundamentals of microbiology and bacterial culture**. The trainee will among others develop skills in project management, experimental planning, hypothesis formulation and testing, scientific communication.
- The candidate will have the **opportunity to continue with a PhD** following the internship (fully funded for 3 years, ERC starting grant BACTODRY).
- For more information or to apply, please send your motivation letter and CV to François Peaudecerf (**francois.peaudecerf@univ-rennes.fr**) and to Nathan Chapelle (**nathan.chapelle@univ-rennes.fr**).
- Informal queries are welcome, and we are keen to hear from diverse applicants.