

M1/M2 internship proposal

Label-free optical imaging of bio films at the liquid-air interface

General information

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Scientific description

The bio films are multicellular tissues made of bacteria and the matrix that they produce. In nature, most of the bacteria lives within bio film bounded to a moist surface. Despite their prevalence a lot still remains to understand the mechanisms underpinning such bacterial self-organization. In particular, the signals and the genetics pathway spurring the formation of a bio film at the air-liquid interface (or mat) are still poorly known. Recent progress in this field (Ardre et al., J. Bact, 2019) decipher at the macroscopic scale the influence of few important genes in this process. However, the gathering of more information at the mesoscopic scale would open avenues for a better understanding of the mat formation.

Currently, it is still difficult to provide a thorough 3D quantification of even simple biophysical parameters (such as bacteria density, speed, bio film volume, etc...). In terms of optical imaging, the bio film operates a transition from a transparent layer to a highly scattering volume, making it complicated to follow individual bacteria over the course of the bio film formation. The most popular imaging techniques involve fluorescence imaging, which is not very robust to scattering, and requires genetic manipulation of the bacteria.

Figure 1: The bio film formation at the air-liquid interface.

Other recent techniques, such as transmission imaging or optical coherence tomography, rely on an intrinsic optical contrast, but fail to provide a sufficient 3D resolution to allow single cell imaging. At the Institut Langevin, we recently developed a new imaging technique, called dynamic full field optical coherence tomography (D-FF-OCT) (J. Scoller et al., J. Biomed. Optics, 2019), that captures the intrinsic scattering contrast of biological objects thanks to a white light interferometer. It offers an almost isotropic 3D resolution around 1 μm , and can efficiently work in highly scattering samples.

The goal of this project is to design and build a new version of the D-FF-OCT setup that would be optimal to follow the bio film formation at the air-liquid interface in a controlled environment. Then, image analysis tools could be developed to automatically quantify useful biophysical parameters and perform bacteria segmentation and classification. Finally, these parameters will be included in a biophysical model of bio film formation.

Figure 2: First observation of a bio film with D-FFOCT.

Expected skills

The project is mainly experimental, and will involve the development of an optical microscope, as well as an incubator to control the bio film environment. General knowledge in physics, and programming are expected, as well as strong interest for the the biophysics interface.