Master 2 research project with available PhD funding

Microfluidic study of bacterial communications in porous media

Labs	Collaboration:	Institute of Fluid Mechanics FR	Géosciences Rennes FR
Funding		ERC Starting grant BEBOP	ERC Consolidator ReactiveFronts
Supervisors		Yohan Davit, yohan.davit@imft.fr	Tanguy le Borgne, tanguy.le-borgne@univ-rennes1.fr
Salary & Dates	Standard stipend of about 500-600 euros/month. Applications until fulfilled. Starting date flexible.		
Publications	[Heyman et al. 2020] Stretching and folding sustain microscale chemical gradients in porous media. PNAS [Smith et al. 2017] Cell morphology drives spatial patterning in microbial communities. PNAS [Kim et al. 2016] Local and Global Consequences of Flow on Bacterial Quorum Sensing. Nat. Microb.		
Background	Experimental fluid mechanics, Microfluidics, Biophysics, Bioengineering, Microbiology.		
Other info	For more info about research activities @ Toulouse, http://yohan-davit.com For more info about research activities @ Rennes, https://reactivefronts-erc.univ-rennes1.fr/		

Background. We are looking for an extremely motivated student who will be fully involved in a multidisciplinary project at the interface between physics, fluid mechanics and microbiology. *We are also looking for someone who is willing to follow up this internship with a PhD thesis (funding available).* Relevant backgrounds for candidates include experimental fluid mechanics, microfluidics, biophysics, bioengineering and microbiology. Whatever the background, the student will have to lead microfluidic experiments with bacterial biofilms, to manipulate pathogenic bacterial cells (*S. aureus*) and to work with complex concepts in fluid mechanics.

Localization. The successful candidate *will be localized in Toulouse.* The team involves 3 other PhD students and 3 postdocs working on the BEBOP project and biofilms. Experimental work is performed in our level 2 biosafety lab at the main university hospital in Toulouse (CHU Purpan).

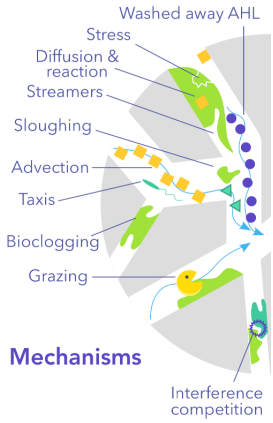

Figure 1: Example mechanisms linked to bacterial growth in porous media. AHL is one of the autoinducers for communications.

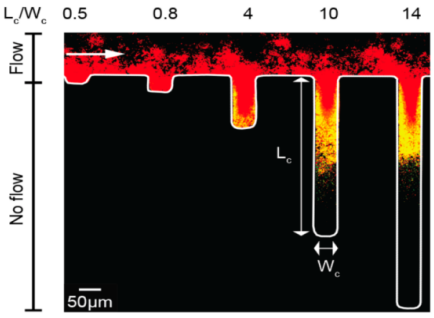

Figure 2: Visualization of Quorum Sensing (red=OFF, yellow=ON) for *S. aureus* under flow in a microfluidic chip with surface roughness. Flow washes autoinducers in zones of large flow whereas QS is activated in primarily diffusive zones. Image from [Kim et al., 2016].

Scientific project. We are studying couplings between fluid flow and mechanisms controlling the development of microorganisms in porous media (figure 1). This project aims at exploring how communications between bacteria, in particular quorum-sensing (QS), are influenced by flow in porous media. Bacteria communicate via signalling molecules, called autoinducers, that are produced by bacterial cells, transported by the flow, diffuse through the different phases and may interact with the solid surface or react. Recent studies [Kim et al., 2016] suggest that the heterogeneities in the flow yield a spatially distributed QS response (figure 2). Furthermore, the Rennes team has recently demonstrated the chaotic nature of flow in porous media [Heyman et al. 2020] and the team in Toulouse has developed novel experimental approaches for studying these problems. This opens opportunities to answering various fundamental questions for communications in complex porous structures, such as: What are the patterns of bacterial communications in porous media? Are there long-distance interactions? Are there strong feedback effects between flow, growth and QS? How does the chaotic nature of the flow affect the communication patterns?

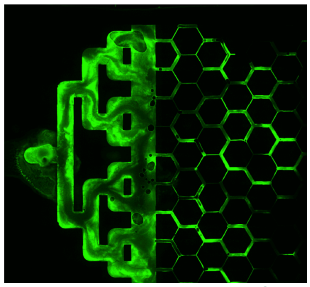

Figure 3: Visualization of *P. aeruginosa PAO1* biofilm under flow in a model hexagonal porous network. Bacteria appear in green as they express a plasmidic GFP.

Role during the project. The student will use experimental microfluidic tools combined with time-lapse fluorescence microscopy (on a Nikon Ti2-E) in order to visualize the spatial patterns of *S. aureus* QS activation in model systems. The mutant of *S. aureus* that will be used for these experiments has two fluorescence colours, allowing us to track cell position and to differentiate between QS-ON and QS-OFF. This mutant is very similar to that in [Kim et al., 2016], as shown

in figure 2, and is already available in the lab. We have also developed different types of microfluidic systems. The student will initially focus on the simplest microfluidic systems at our disposal, a single channel and a bifurcation, before moving on to more complex porous networks (figure 3). Of course, the work also includes a bibliographic study, data post-processing, results analysis, theoretical considerations and active discussions within the team and with collaborators.

PhD follow up. If the internship is successful, we intend to continue with a PhD thesis, moving towards more complex porous structures and chaotic mixing [Heyman et al., 2020]. Salary is about 20 600 euros net/year. *This PhD will be localized in Toulouse for the first half of the PhD and in Rennes for the second half.*

Research context and projects. This work is a collaboration between the Institute of Fluid Mechanics of Toulouse and the Geosciences laboratory in Rennes. The research project is based on two large European projects funded by the European Research Council (ERC StG BEBOP in Toulouse PI Y. Davit & CoG ReactiveFronts in Rennes PI T. le Borgne). BEBOP aims at developing new generations of biotechnologies, such as self-repairing construction materials or self-cleaning bioreactors, that rely on the *use of bacteria to control the properties of porous structures*. The goal of ReactiveFronts is to study the *dynamics of biogeochemical reactions induced by fluid mixing in subsurface environments*, to explore hot spots of chemical reactions and microbiological activity the environment.

How to apply? Please send a CV, all available grades/ranks and, if available, recommendation letters from previous advisors to yohan.davit@imft.fr and tanguy.le-borgne@univ-rennes1.fr. Please make sure to title the mail as “application_to_Master_QS”.