PhD position
Microfluidic study of bacterial communications in porous media

Labs	Collaboration between: Institute of Fluid Mechanics Toulouse FR	Géosciences Rennes FR
Funding	European Research Council: Toulouse, Starting grant BEBOP	Rennes, Consolidator ReactiveFronts
Supervisors	Yohan Davit, yohan.davit@imft.fr	Tanguy le Borgne, tanguy.le-borgne@univ-rennes1.fr
Salary & Dates	About 20 600 euros net/year. Applications until fulfilled. Starting date is in Autumn 2021, but flexible.	
Relevant publications	[Heyman et al. 2020] Stretching and folding sustain microscale chemical gradients in porous media. PNAS [Dehkharghani et al. 2019] Bacterial scattering in microfluidic crystal flows reveals giant active Taylor–Aris dispersion. 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	Microfluidics, Biophysics, Bioengineering, Microbiology or Bacterial ecology.	
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. The relevant background includes experimental fluid mechanics, microfluidics, biophysics, bioengineering, microbiology or microbial ecology. Experience in bacterial cell culture and microfluidics is required.

Localization and duration. The successful candidate *will be localized in Toulouse for the first half of the PhD and in Rennes for the second half.* The team in Toulouse includes 2 other PhD students and 2 postdocs working on biofilms. The team in Rennes includes 3 PhD students and 4 postdocs.

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 and numerical approaches for studying these problems (Smith et al. 2017). This opens opportunities to answering various fundamental questions for communications in complex porous structures i.e.: What is the network of communications in porous media? Are there long-distance interactions? How does the chaotic nature of the flow affect the patterns of communications?

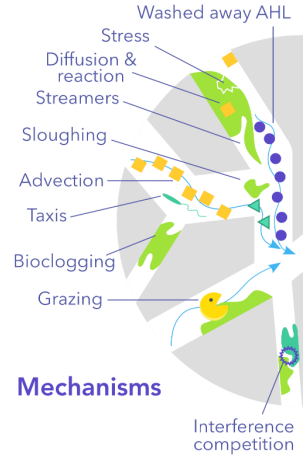

Figure 1: Example mechanisms linked to bacterial growth in porous media. AHL is one of the autoinducers for communications.

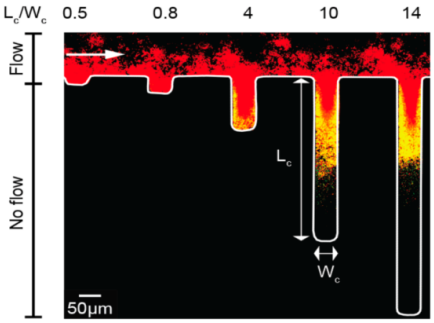

Figure 2: Visualization of Quorum Sensing (red=OFF, yellow=ON) for *S. aureus* under flow in a microfluidic chip with surface roughness. Flow washes autoinducers in zones of large flow whereas QS is activated in primarily diffusive zones. Image from [Kim et al., 2016].

Role during the project. The student will use novel experimental and simulation tools developed by the two groups in order to study bacterial communications in porous media. The core of the work is experimental and based on microfluidics. We are currently developing different types of microfluidic systems, along with bacterial mutants allowing us to visualize QS by fluorescence microscopy. The successful candidate will work in a safety level 2 biology laboratory, manipulate microorganisms such as *Pseudomonas aeruginosa* PAO1 or *Staphylococcus aureus*, and participate actively to discussions within the team and with biologists.

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*. ReactiveFronts focuses on 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 apply directly on the CNRS website emploi.cnrs.fr: https://bit.ly/2SNvKNX