Swimming in fluctuating lanes:
How do bacteria navigate changing environments?

Microorganisms, such as bacteria or microalgae, are often found in complex environments: from maze-like structures in soils to serpentine channels in the intestine. Such microorganisms consume energy to swim and navigate effectively across landscapes. Numerous works have characterized the motion of microorganisms in the bulk. However, studies in realistic environments remain scarce. Recently [1], it was found that bacteria in porous media (a microscale maze-like 3D structure) exhibit a very peculiar behavior (see Fig. 1). In fact, compared to standard passive particles, bacteria get trapped in specific spots. This is due to the time it takes them to flip their swimming direction.

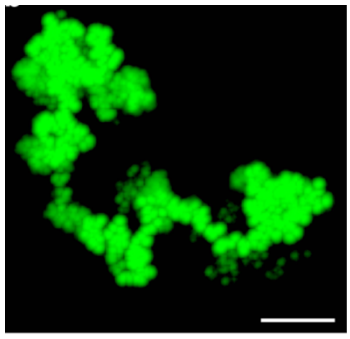

Fig.1. A bacteria trajectory in 3D porous media. Scale bar 5µm. From [1]

Most investigations explore only static environments. Yet, in Nature, environments dramatically evolve in time: from rainfalls which induce flows to soil mazes that continuously reorganize due to the presence of other microorganisms which create jams or open up pathways.

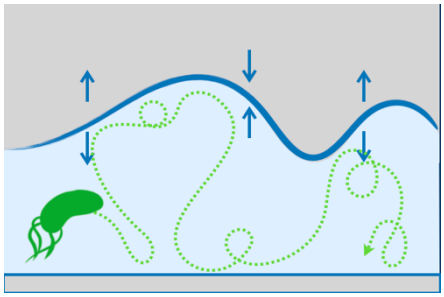

Fig.2. Sketch of the model: a bacteria in a fluctuating line

To investigate the motion of microorganisms in such fluctuating environments, we will explore a minimal model of active particles moving through a wiggling channel (=swimming in a fluctuating lane, Fig. 2). We will study the diffusion and the drift of the particles according to the speed of the fluctuations [2]. We expect to uncover interesting regimes where motion is increased by collisions with the channel walls. We also expect odd behaviors associated with the interplay between different time scales in the system. We will characterize these different regimes. This internship will be in collaboration with Ruben Zakine (Ecole Polytechnique).

The results could broaden our understanding in microorganism motion, which has biomedical and industrial applications.

The internship can lead to a PhD, with the aim of understanding how microorganisms modify their environments. This has applications in **soil remediation**, such as in analyzing how fast pollutant compounds are consumed by microorganisms or in **biodegradation such as in composts**.

Tools used: Analytical work and/or stochastic simulations, related to soft matter/statistical/biological physics

A few references

[1] T. Bhattacharjee, S. Datta, Nature Comm. 2019, https://doi.org/10.1038/s41467-019-10115-1

[2] S. Marbach, D. Dean, L. Bocquet, Nature Phys. 2018, https://doi.org/10.1038/s41567-018-0239-0

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