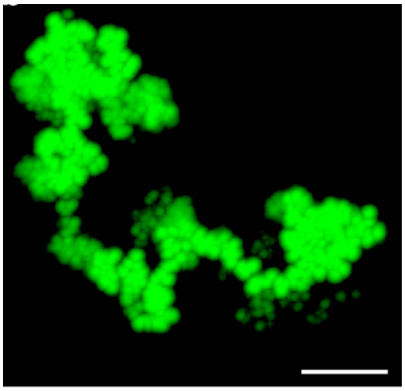
Swimming in fluctuating lanes

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. They are named active particles. 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, see picture) exhibit a very peculiar behavior. 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.
Be that as it may, most investigations explore only static environments. Yet, especially in Nature, environments are not static but fluctuate in time. For example, soil mazes continuously reorganize due to the presence of other microorganisms which create jams or open up pathways.

To investigate the motion of microorganisms in such fluctuating environments, we will explore a minimal system of active particles moving through a long wiggling channel (=swimming in a fluctuating lane). We will study the diffusion and the drift of the particles according to the speed of the fluctuations. We expect interesting limiting regimes where motion is increased by collisions with the channel walls [2]. 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 (CFM Foundation). The intern will also have the option to model experimental active environments, with flow fields generated by rotating rods (Jérôme Fresnais, Phenix lab).
The results could broaden our understanding in microorganism motion, which has numerous biomedical and industrial applications.



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

The internship can lead to a PhD, with the aim to understand how microorganisms modify their environments. This has applications in soil purification, such as in analyzing how fast pollutant compounds are consumed by microorganisms.

Tools used: Analytical work in Stat Phys and/or stochastic simulations, depending on preferences

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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