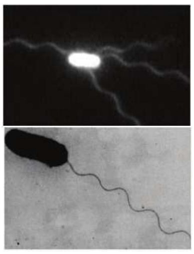
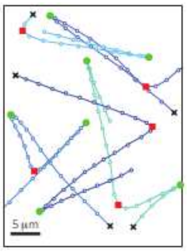
Master 2 internship

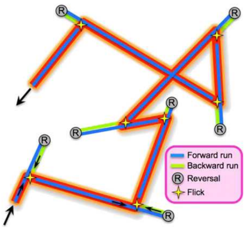
Random walks of swimming bacteria

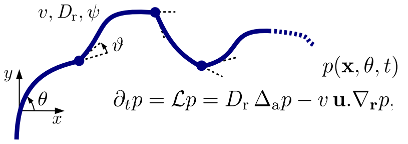
Endowed with one or several flagella driven by rotary motors, many bacteria are restless micro-swimmers. The canonical example of swimming pattern is the run-and-tumble of *Escherichia coli* [1], with bouts of persistent swimming (run) interrupted by reorientation (tumble). Current research is revealing that such run-and-tumble random motion is a theme with many variations : bacteria display a fascinating repertoire of swimming strategies. Why is this so ?

As one of the fundamental model of statistical physics, random walks is a topic rich of a long history [2]. Yet, except for particular cases, the statistical properties for many bacteria swimming patterns have long eluded analytical prediction. Even the mean-square displacement, a quantity of basic importance in experiments, could not be obtained in closed form. Extending the framework of continuous time random walks [3], we have recently proposed a method to obtain those analytical properties [4].









$$\partial_t p = \mathcal{L}p = D_\mathrm{r}\, \Delta_\mathrm{a} p - v\, \mathbf{u}.\nabla_\mathbf{r} p.$$

$$\boxed{P(\mathbf{q}, s) = \left[\psi_\chi(\hat{\mathcal{L}}) + \frac{\overset{3}{\psi}_\beta(\hat{\mathcal{L}})[h(\mathbf{q})\psi_\alpha(\hat{\mathcal{L}})]^{1}}{[1 - h(\mathbf{q})\psi(\hat{\mathcal{L}})]^{2}} \right] P_\mathrm{in}(\mathbf{q}).}$$

The goal of the internship is to build on this approach to explore new situations : bacteria swimming in external fields, in confinement and chemotaxis, thus allowing to gauge the strength of each swimming strategy. The work is mainly analytical, complemented by numerical simulations. Predictions will be useful not only for swimming bacteria but also in a variety of contexts : cell motility, animal motion or foraging strategies.

This internship thus be pursued as a PhD program, depending on funding opportunities.

[1] *E. coli in motion*, Berg H.C. (2004).

[2] Random walk models in biology. Codling E. et al., *J. R. Soc. Interface* (2008).

[3] *First steps in random walks*, Klafter J. and I. M. Sokolov (2011).

[4] Non-Poissonian run-and-turn motions, Detcheverry F., *EPL* (2015).

Key-words : random walks, run-and-tumble, bacteria swimming, cell motility, chemotaxis.

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