Simulations of Microswimmers in Liquid Crystals

Laboratoire Ondes et Matière d'Aquitaine (LOMA) Université de Bordeaux

Juho Lintuvuori (juho.lintuvuori@u-bordeaux.fr) ; Alois Würger (alois.wurger@u-bordeaux.fr)

Understanding how to direct and control self-motile objects is a grand challenge in soft matter physics. Mastering this could lead to the development of novel materials, where the constituents can carry-out task autonomously without an outside intervention. Pioneering experiments [1] and simulations [2] have demonstrated that fluid topology, such as orientational (nematic) order of liquid crystals, can be used to guide microswimmers (Fig. 1).

In this project, we will study in detail the hydrodynamics of microswimmers in a complex environment e.g. in liquid crystals, using both hydrodynamic simulations and analytical calculations. The project will build on a recently developed combined simulation/theory model for spherical microswimmers in a nematic liquid crystal [2] (Fig. 1D).

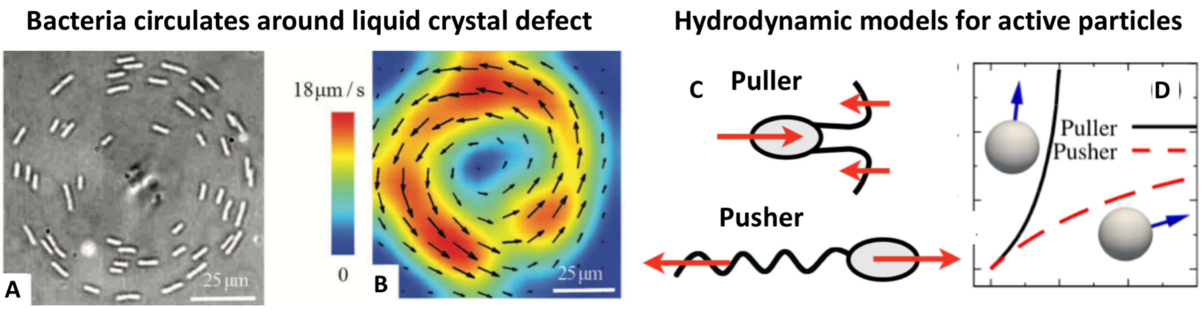

Fig. 1 Guiding bacteria with liquid crystal topology (A-B): Experimentally, a rod-like bacteria (Bacillus subtilis) is observed to swim around liquid crystalline defect with a speed of ~10μm/s [1]. Hydrodynamic swimming mechanisms of bacteria (C): A puller (e.g. Chlamydomonas) is propelled from front, while pusher (e.g. E. coli or bacillus subtilis) is propelled from behind (figure from [3]). (D) Spherical microswimmers can align hydrodynamically in a *uniform* nematic liquid crystal [2].

Questions to be addressed within this project include: (**i**) Consider non-uniform director configurations e.g. mixed bend/splay to direct the swimmers using lattice Boltzmann simulations [2] and compare to the bacterial experiments [1] (see also Fig. 1A and B). (**ii**) Understanding the effects of chirality of the swimming medium (cholesteric LC) and finally (**iii**) a fluid with topological defects in equilibrium (e.g. LC blue phases) can be considered.

The project would suit candidates who are interested in simulations of (active) soft materials. It can be either simulation or theory oriented, depending on the interest of the candidate(s). The project(s) offer a rich research environment including a strong cross fertilisation between simulations and theory, as well as the possibility to gain an experience in state-of-the-art simulation techniques (e.g. lattice Boltzmann).

In addition to the master project, there is also a possibility for a PhD funded by an existing ANR grant.

Informal enquiries are very welcome and should be addressed to Juho Lintuvuori (juho.lintuvuori@u-bordeaux.fr) ; https://www.loma.cnrs.fr/juho-lintuvuori/

[1] Peng *et al. Science* **354**, 882 (2016).
[2] Lintuvuori, Würger & Stratford, *Phys. Rev. Lett.* **119**, 068001 (2017).
[3] E. Lauga and T. R. Powers, *Rep. Prog. Phys.* **72**, 096601 (2009).