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## Collective behavior of Magnetotactic bacteria : rheology and jamming

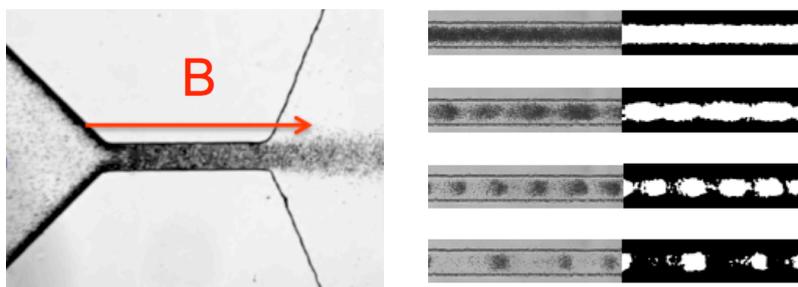
Many organisms have the ability to move with fascinating collective effects (flock of birds, school of fishes, human crowd, etc.). Although these intrinsically **out of equilibrium systems** have been the object of many recent studies, many open questions subsist as of their understanding, that motivate continuous efforts in various fields : statistical physics, fluid mechanics, etc.

So far, a great part of studies has dealt with the spontaneous properties of the systems. However, very interesting phenomena seem to occur when looking how these systems respond to external stimuli or constraints. Experimentally, very few systems exist that allow imposing controlled forcing to an active particles assembly. Recently, we took advantage of a peculiar biological organism to produce such a controllable active system.

Among swimming micro-organisms, magnetotactic bacteria are particularly interesting because upon *their natural swimming motion they can be externally driven* with a simple magnet. In the presence of an external magnetic field, they swim along magnetic field lines, with a typical velocity of the order of  $70\mu\text{m/s}$ . These active particles are very appealing as an additional external parameter (the magnetic field) allows to control their drift direction. In a preliminary study we have recently shown that the statistics of orientation of individual magnetotactic bacterium is well described by a Langevin model.

Ongoing work addresses now the question of the collective motion of a population of bacteria under constraints or forcing looking at the (hydro-)dynamics of active matter. For instance, recent observation in our group demonstrated a pearling instability of a suspension of swimming magnetotactic bacteria flowing against a hydrodynamic flow, which recalls classical hydrodynamic instabilities [1]. The conditions of existence of this instability have been identified but it needs to be characterized and further described.

**The aim of this internship** will be to unravel, by a combined experimental and theoretical study, the underlying mechanism for this pearling instability and to study the jamming properties of this active system.



*Left : jamming of magnetotactic bacteria in a funnel*

*Right : pearling instability for a suspension of magnetotactic bacteria is against a hydrodynamic flow*

**This internship will involve** state of the art optical microscopy, microfluidics, image processing, statistical physics and fluid mechanics. **This subject could be extended for a PhD.** It could be developed in connection with theoretical aspects of active systems.

[1] Destabilization of a flow focused suspension of magnetotactic bacteria PRF 1, 053203 (2016)