Capillary forces and out-of-equilibrium physics in the collective spreading of bacteria

Intership proposal — Master 2: International Centre for Fundamental Physics

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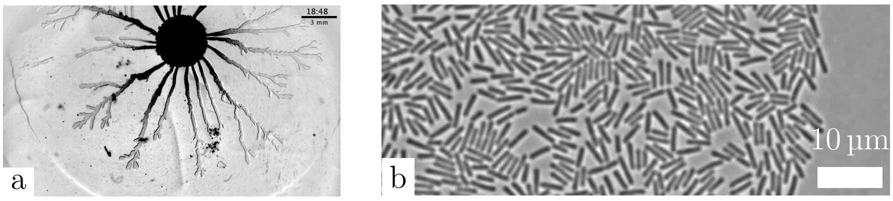
Thesis possibility after internship: oui *Thesis funding:* no

The generalisation of equilibrium statistical physics to active (out-of-equilibrium) systems is a central challenge for contemporary physics. Living systems are such active systems, in which the collective behaviour of millions of cells leads to spatial self-organisation, from bacterial colonies to the organs of mammals. Very few biological systems however provide the understanding of cell-level interactions that is required for a coarse-graining procedure that would predict the global behaviour.

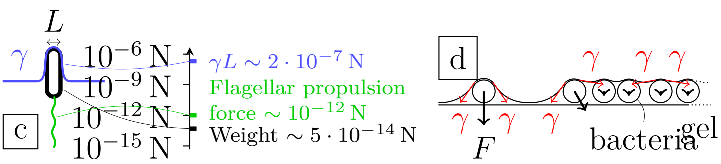


[images: K. Hamze, S. Séror, B. Holland & A. D.]

(a) Dendritic spreading of bacteria from the mother colony (centre-top of image). (b) Microscopic detail of a dendrite tip. Note the sharp boundary delimiting the dense population from the void exterior.

Here we propose an experimental investigation of a particular surface-bound spreading mechanism of bacteria (Bacillus subtilis) termed 'mass swarming' (image (a) above), whose confinement to two dimensions (b) and the large number of genetically identical individua make it an ideal model system of active matter. Our aim is to determine the physical mechanisms at work quantitatively.

Capillary forces are dominant in this surface-bound translocation mode (c), so much that individual cells cannot leave the colony without being immobilised (d). Migration is possible only collectively, by the 'pressure' that the 'hot' bacterial bath exerts on its boundary. Tuning the capillary forces by controlling the pressure inside the gelose nutrient medium, we will monitor the change in spreading dynamics. We aim in particular at identifying the depinning threshold for the colony perimeter, which can be described as a hysteretic wetting phenomenon.



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Condensed matter physics: no *Soft matter and biological physics:* yes
Quantum physics: no *Theoretical physics:* no