FAST Fluides, Automatique et Systèmes Thermiques — université PARIS-SACLAY — cnrs

Proposal for a Master 2 internship

Hydrodynamic instabilities in bacterial suspensions

with Carine Douarche (**carine.douarche@universite-paris-saclay.fr**)
& Frédéric Doumenc (**frederic.doumenc@sorbonne-universite.fr**)
Laboratoire FAST, Université Paris-Saclay, CNRS 91405 Orsay, France

The drying of a liquid film of polymer solution can cause the formation of natural convection cells organized in regular patterns (cf. Fig.1a and ref.[1]). During drying, the solvent evaporates while the non-volatile polymer concentrates at the surface of the film. This can lead to an unstable situation if the polymer has a higher density and/or surface tension than the solvent, resulting in the movement of the solution (Rayleigh-Bénard-Marangoni instability [2]).

By studying suspensions of bacteria, we observed the formation of patterns reminiscent to those observed in polymer solutions (cf. Fig.1b and ref.[3]). In particular, in both cases, the size of the convective cells is proportional to the thickness of the liquid film. However, the analogy with polymers is very imperfect, and the different physical phenomena at work in the case of bacteria are still largely not understood. Unlike polymers, bacteria are active particles that locally consume energy and thus constitute a dynamic system interacting with its environment.

The objective of the internship is to study the physical phenomena involved during the growth of a bacterial suspension to understand the origin of the observed instabilities. A device for observing the system using video microscopy will be developed and coupled with image analysis methods. The results of this study of the heterogeneous and collective dynamics of bacteria will help broaden our understanding of microorganism colonization.

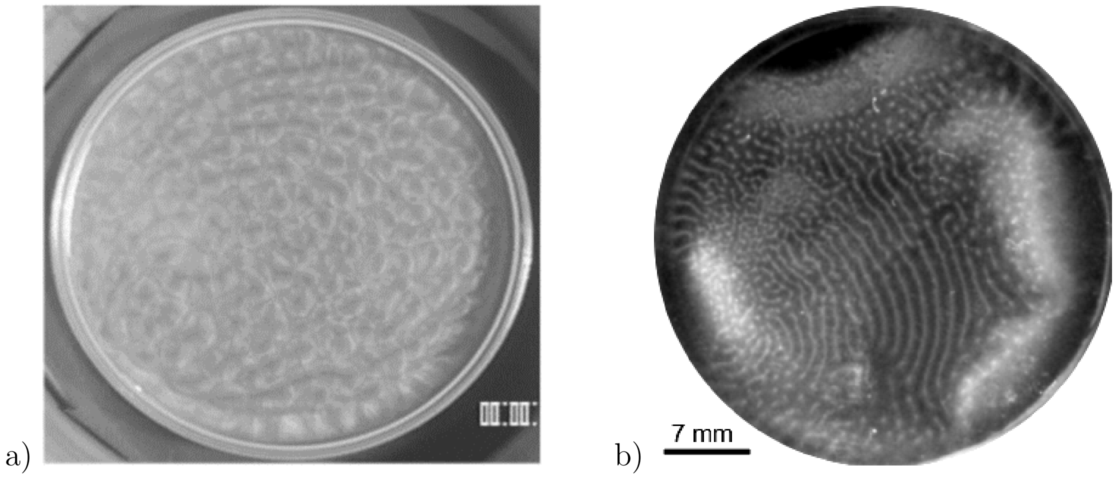

Figure 1: a) Convective cells in a drying polymer solution (diameter of the dish: 11 cm) [1]; b) Convective cells in a bacterial suspension.

References

[1] Experimental characterization of buoyancy- and surface tension-driven convection during the drying of a polymer solution (2008) G. Toussaint, H. Bodiguel, F. Doumenc, B. Guerrier, C. Allain. *International Journal of Heat and Mass Transfer*, 51, 4228-4237.

[2] Physical hydrodynamics (2015) E. Guyon, J.P. Hulin, L. Petit, C.D. Mitescu. *Oxford*.

[3] Evaporation-driven convective flows in suspension of nonmotile bacteria (2018) J. Dunstan, K. L. Lee, Y. Hwang, S. F. Park, R. E. Goldstein. *Phys. Rev. Fluids* 3, 123102.