

Flow field of convection cells formed by magnetotactic bacteria

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Abstract

One of the most characteristic behaviors of a group of active agents (entities that are able to consume energy in order to move) is their ability to generate collective motion [1], transforming the individual agents into a group with its own attributes. One prominent example of this is the behavior of bacterial suspensions. When diluted, each bacterium mainly interacts through excluded volume with other bacteria. However, when the density of bacteria is high, collective behavior emerges in the form of bioturbulence [2].

An example for this is the collective behavior of magnetotactic bacteria (MTB) in the presence of a magnetic field. MTB have an elongated helicoidal body flanked by two polar flagella. Inside their body, MTB synthesize an array of magnetic nanoparticles, that confer them with the ability to follow magnetic field lines. By rotating either flagellum, MTB swim by pushing their surrounding fluid and present a persistent random motion if undisturbed. In the presence of an external magnetic field, they align their swimming direction with the field lines. In this condition, a dense suspension of motile magnetotactic bacteria organize and form convection cells, as seen in Figure 1. We are currently studying the patterns formed in these cells when a uniform magnetic field is suddenly applied in a homogeneous, dense suspension of MTB confined in the small gap between two parallel solid boundaries.

To understand the evolution of the convection cells, the flow field of the convection cells is studied with particle image velocimetry. We have built Helmholtz coils to apply the magnetic field to the bacterial suspension and use fluorescent particles to trace the flow field under the microscope.

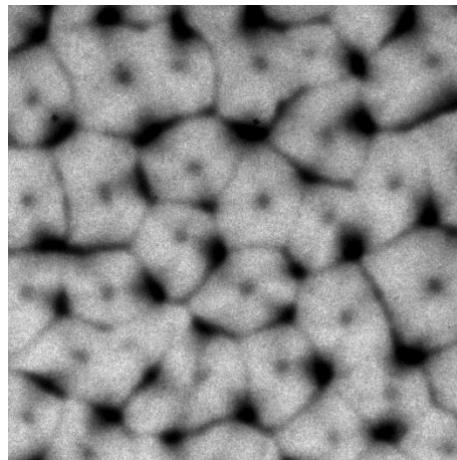


Figure 1: Convection cells formed by magnetotactic bacteria. The gray level correlates with bacterial concentration, with darker regions corresponding to higher concentrations.

References

- [1] T. Vicsek et al. Phys. Rev. Lett. 75, 1226 (1995)
- [2] H. H. Wensink et al., PNAS 109, 14308-14313 (2012)