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Natural and self-assembled swimmers

Résumé
Bacteria, like E. coli, constitute a natural example of self-propelled objects. The permanent energy flux from the fuel, to the swimmers and lately to the fluid, puts these systems in permanent non-equilibrium conditions. Swimmers constitute paradigmatic examples of active matters and constitute an interesting playground for non-equilibrium matter. In this talk I will describe the properties of natural (E. coli) and artificial self-assembled (colloidal) swimmers.

When bacteria are placed in confined environments they are attracted to solid surfaces and swim in contact with them for long times. In this talk, several aspects related to the motion of bacteria near surfaces are considered. First, a simple swimmer model will be introduced, which reproduces the main features of bacteria-surface interaction including the observed circular motion. Second, the induced diffusion of tracers in presence of a bacterial bath is studied. A kinetic theory combined with a hydrodynamic approach allow us to compute the resulting diffusivity. It is shown that close to surfaces, the induced diffusivity is enhanced as a result of the smaller swimming efficiency of bacteria.

Artificial swimmers are also possible to build. In this talk the case of self-assembled colloidal particles is described.
Catalytically active colloids maintain non-equilibrium conditions in which they produce and deplete chemicals. The concentration fields resulting from the chemical activity produce gradients that attract or repel other colloids depending on their surface chemistry and ambient variables. This results in a non-equilibrium analogue of ionic systems, but with the remarkable novel feature of action-reaction symmetry breaking. In dilute conditions they join up to form (colloidal) molecules. The molecules could be inert or have spontaneous activity in the form of net translational velocity and spin depending on their symmetry properties and their constituents. Also, oscillatory states are possible as well as spontaneous transitions from active to passive states, mimicking the run-and-tumble motion of bacteria.

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