Master 2 Internship

Title: Active fluctuations induced by artificial nanomotors

Type: experimental

Supervisor(s): Antoine Aubret (CR CNRS) and Yoann De Figueiredo (PhD student).

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PhD funding (if any): Yes (ANR NanoDArt 2025-2029)

Project: Living systems transduce energy to operate, forming examples of Active Matter. Biological cells, for instance, behave as complex micro-factories, driven by internal nanomotors. The latter move, interact, bump and generate coordinated forces on the membrane. Designing equivalently complex micromachines constitutes an outstanding challenge, which requires understanding how to generate work from the bottom-up.

At the LOMA, we have recently developed artificial nanomotors. They are formed by self-propelling and asymmetric nanoparticles. The nanomotors generate and harness thermal gradients to propel in 3D, and reach velocities up to ~ 200 µm/s. Thanks to their self-propulsive dynamics; they can generate forces on microscale objects.

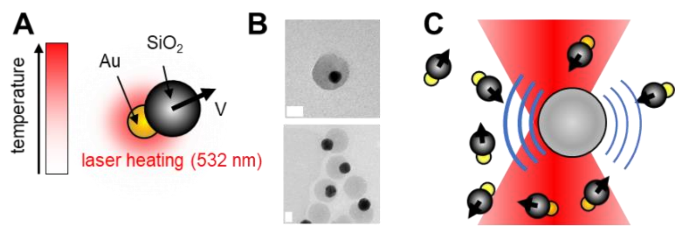

Figure: Self-propelling nanomotors.
A) *Scheme of the propulsion scheme.* A 532 nm laser heats the metal part of the nanoparticle, enabling propulsion by thermophoresis. **B)** *Transmission Electron Microscopy images* of the nanoparticles synthesized in the lab (scale bar 50 nm). **C)** *Scheme of the project*: active particles bump and exert forces on a passive object, optically trapped (red laser). Analysis of the position of the object informs on its non-equilibrium dynamics.

The aim of this internship is to investigate the influence of a bath of active nanomotors on the dynamics of a passive microbead. Due to the presence of an active bath and internal energy input, the dynamics of a passive tracer is far-from-equilibrium, and expected to differ from Brownian motion. Our strategy uses light and photothermal heating (induced by laser) to generate propulsion. This enables accurate control of the activity, in the absence of fuel, and the construction of 3D active baths made of statistical ensemble of nanomotors.

The trainee will study how the dynamics of the bead can be connected to the non-equilibrium properties of the active bath, in particular in terms of macroscopic quantities such as active pressure and temperature. The goal is to extract relevant protocols to further harness a nanoscale active fluid in 3D to generate work.

The objectives of the internship are:

-Calibrate the active fluid by measuring the individual propulsion of the nanoparticles.

-Develop an optical trapping setup to trap a passive bead, and excite the nanoscale active fluid simultaneously.

-Follow the dynamics the dynamics of the bead by varying the activity and density of the bath, using tracking experiments.