Master 2 Internship

Title: Active matter at the nanoscale: probing the dynamics of a 3D active gas.

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PhD funding (if any): PhD funding may be available depending on results to various calls.

Project: Active matter consists in collections of self-driven units that convert energy into motion and work. Cells, for instance, use molecular nanomotors to transduce energy at the nanoscale, which enables cellular organization at larger scale. This biological complexity has motivated the development of artificial analogs, a major goal in material science. Recent progresses in colloidal science have triggered the development of micrometric, self-propelled particles. These particles could show emergent behaviors such as the formation of flocks, or herds. However, most of the current active matter use micrometric particles that restrain studies to specific, 2D systems.

The study of active matter in 3D is yet essential to increase the complexity of active materials and explore novel physical concepts such as active pressure and temperature. In this context, **we propose here to scale down the elementary building blocks and use self-driven nanoparticles**. As nanoparticles exhibit weak sedimentation, they can be used as bricks of larger, 3D active matter systems.

The aim of this internship is to explore the individual and collective dynamics of self-propelled nanoparticles. The Optoflow group at the LOMA has recently developed a method to synthesize metal/semiconductor nano-heterodimers (< 50nm). Their nanometric size and their asymmetry enables their self-propulsion by laser heating and in 3D. These particles thus offer a privileged platform for the design of a 3D active gas with optically tunable properties. The challenge in this study is two-fold: i) disentangle the motion due to the activity of the particles from the high thermal noise at this scale and ii) investigate the ensemble dynamics when the particles cannot be individually resolved. To this end, the trainee will implement and use nano-optical correlation techniques, such as fluorescence correlation spectroscopy coupled to fast tracking and imaging. They will work on setting up the experiment, performing calibration measurements, as well as collect important preliminary data on the nano-heterodimers to build, for the first time, an optically controlled and 3D active gas.

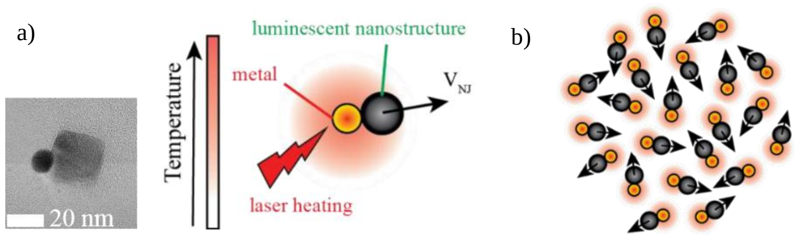

Figure1: a) TEM image and scheme of the nano-heterodimer used in the study. Upon heating of the metal part, the particle self-propels by thermophoresis – the motion of a particle in a temperature gradient. b) An assembly of self-propelled nanoparticles can yield to emergent behavior in 3D.