Proposition de stage de Master 2

Dynamics of a levitated particle in an optical arbitrary potential

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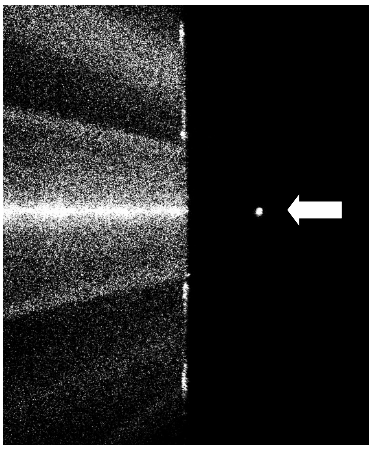

50 nm particle optically trapped (arrow) by a strongly focused laser beam. The focusing objective can be seen on the left.

The Nobel Prize has just been awarded to Arthur Ashkin for his work on optical tweezers. Trough the numerous applications of optical tweezers, the development of vacuum levitated particles has known an active research activity over the last few years. Such an interest can be explained by the important promises of this system, from the study of fundamental interactions [1], to the effect of gravity on quantum systems [2] through the study of thermodynamics at the nanoscale [3,4].
For this last research axis, the unique control that one can apply to a levitated particle and its environment is undoubtedly a major asset [4]. Especially, the optical potential can be finely tuned, toward the generation of almost arbitrary energy landscapes. Indeed, optical tweezers are based on optical forces associated with a strongly focused laser beam (Fig1). A simple Gaussian beam will then provide a harmonic potential. A careful engineering of the light field can, in principle, provides any given optical potential. Until now, this aspect have been mostly unexplored in the case of levitated particles.
In this context, the present project aims at trapping a nanoparticle in an arbitrary potential. As a first step, we propose to use a simple bistable potential. The effect of potential shape and particle environment (damping, temperature,…) on the particle dynamics will be investigated. Such a study will unravel conditions under which particle diffusion can be favoured [4].
Besides, such an optical potential can also be used to trap multiple particles. This will lead to the study of the interaction between two particles with unprecedented precision, as well as the study of energy flows between them [5].

This project could be continued as a PhD project.

Références :

[1] Gieseler, et al. “Thermal nonlinearities in a nanomechanical oscillator” *Nat Phys* **9,** 806 (2013).
[2] Kaltenbaek, *et al.* “Macroscopic Quantum Resonators (MAQRO): 2015 update” *EPJ Q. Tech.* **3** (2016).
[3] Gieseler et al. ‘Levitated Nanoparticles for Microscopic Thermodynamics - A Review.” *Entropy* **20,** 326 (2018)
[4] Rondin, et al. “Direct measurement of Kramers Turnover with a levitated nanoparticle” *Nat Nano.* (2017).
[5] Bérut et al. *“Stationary and Transient Fluctuation Theorems for Effective Heat Fluxes between Hydrodynamically Coupled Particles in Optical Traps.” Phys. Rev. Lett.* **116,** 068301 (2016).