PhD subject
Proposed by the group « Nanopinces » of LCAR (Université de Toulouse/CNRS UMR 5589)

Study of a nanosphere trapped in an optical tweezer : Cooling and manipulation of its motion by optical and electric forces

PhD supervisor: Matthias Büchner
Contacts : matthias.buchner@irsamc.ups-tlse.fr ☎ : 05 61 55 76 74

In 2018, Arthur Ashin received the Nobel prize for his ground breaking research on optical trapping of particles, bacteria, virus and living cells using highly focused lasers: The sol called “Optical tweezers” became an universal tool.

The proposed PhD deals with such an optical tweezer. Our tweezer will trap nanoparticles of masses between 10^6 et 10^9 a.m.u. These particles form a bridge between the macroscopic world, governed by classical mechanics, and the microscopic world, governed by quantum mechanics. The question of decoherence of these nanoparticles is intensively discussed in literature, mainly decoherence induced by gravitation [2]. These nanoparticles are also very suited for probing ultra-weak external forces.

The goal of the proposed experiment is to trap a silica nanopearl by a 1550 nm cw laser and to manipulate its centre of mass motion by optical and electric field. Silica is particulary suited as the coupling between external and internal degrees of freedom (heating !) are only weakly coupled. In literature, it is reported that the centre of mass motion can be frozen to some mKelvins and thanks to this low temperature, forces of about some zeptoNewton (10^{-21} N !) acting on the nanosphere may be probed [3].

The candidate will mainly work of the experiment, testing and first experiments on nanopearls between 1 µm and 150 nm. He/she will continue the mounting of the optical system for the motion detection and the system for freezing. During the PhD, the candidate will apply electric forces on the nanopearl in order to manipulate (to freeze) its motion. The application of such forces is original and will provide an additional tool for the manipulation of the nanoparticle.
This work can be easily extended, even during the PhD: trapping other nanoparticles by the same trap, trapping several nano-objects simultaneously… the possibilities are numerous.

Literature :
[1] https://www.lemonde.fr/prix-nobel/article/2018/10/02/nobel-de-physique-trois-scientifiques-dont-un-francais-recompenses-pour-leurs-travaux-sur-les-lasers_5363327_1772031.html
[2] On Gravity's role in Quantum State Reduction *R. Penrose,* Gen. Rev. Grav. **28**, 581 (1996)
[3] Subkelvin Parametric Feedback Cooling of a Laser-Trapped Nanoparticle
J. Gieseler, B. Deutsch, R. Quidant, L. Novotny, Phys. Rev. Let. **109,** 103603 (2012)