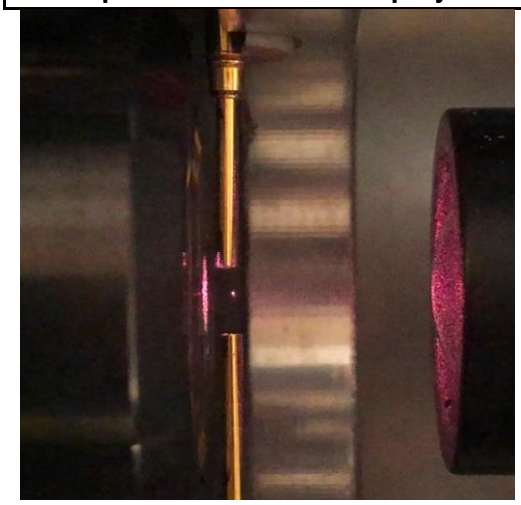
Person in charge of the internship: Loïc Rondin
Tel:
e-mail: loic.rondin@universite-paris-saclay.fr

Ultra sensitive force sensing with levitated particle

Description of the scientific project:



The development of increasingly sensitive force probes is essential both from an application perspective (smartphones' accelerometers, gravimeters for monitoring Earth's climate [1], etc.) and from a fundamental perspective (measuring forces beyond the Standard Model [2]). To address these questions, it is necessary to have a force sensors that is simple, robust, and highly sensitive. A promising approach is the levitation of particles in a vacuum, which allows for very high sensitivities due to the weak coupling between the particle and its environment. Levitation relies on an optical trap, which uses the forces associated with a laser beam to trap a nanoparticle at the focal point of a objective (see figure). The particle then behaves like a mechanical oscillator with a very high-quality factor, making it highly sensitive to applying an external force.
In this context, this project aims to develop a force sensor based on optical levitation and demonstrate its sensitivity, particularly in the measurement of gravity. Depending on their interests, the student involved in the project may choose to focus either on developing a prototype of an integrated and portable accelerometer or on pushing the force measurement sensitivity to fundamental classical and quantum limits, in order to measure gravitational forces beyond currently accessible sensitivities.

This project will build on recent developments in the laboratory and on the strong international research momentum surrounding particle levitation, driven not only by the incredible properties of this system for force measurement, but also by its applications in studying quantum physics at our scale, as well as in nanothermodynamics [3].

References :
[1]Mission GRACE et GOCE (ESA /NASA)
https://www.esa.int/Applications/Observing_the_Earth/FutureEO/Taking_climate_monitoring_into_the_future_with_quantum
[2] Moore and Geraci. "Searching for New Physics Using Optically Levitated Sensors." Quant. Sci. Tech. 6, no. 1 (2021) (2020). https://arxiv.org/abs/2008.13197
[3] Gonzalez-Ballestero et al. « Levitodynamics: Levitation and control of microscopic objects in vacuum. » Science 374, eabg3027 (2021). https://arxiv.org/pdf/2111.05215.pdf

Methods and techniques: optical tweezers, optical levitation, nano-optics and photonics.

Possibility to continue as a PhD student ? YES
PhD grant available ? NO