

INTERNSHIP PROPOSAL

Laboratory name: Laboratoire de Physique des Lasers, CNRS-Université Sorbonne Paris Nord, Villetaneuse
CNRS identification code: UMR 7538
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Web page: <https://www.lpl.univ-paris13.fr/en/research/interferometry-and-optics-for-atoms-oia/>
Internship location: Laboratoire de Physique des Lasers
Thesis possibility after internship: YES

Probing fundamental forces with cold atoms and nanostructures

What happens when an atom comes close to a surface?

This apparently simple question lies at the intersection of quantum physics, nanoscience and fundamental physics. At short distances, an atom does not simply “see” a material surface: it interacts with the quantum fluctuations of the electromagnetic field surrounding it. These fluctuations give rise to the **Casimir–Polder force (C–P)**, a quantum force whose behaviour in the nanometer range still raises fundamental questions. Furthermore, at short distances, deviations from known interactions could reveal new physics, such as hypothetical **fifth forces** predicted by several extensions of the Standard Model.

In this context, at the Laboratoire de Physique des Lasers, we have developed an experiment in which a laser-cooled atomic wave interacts with a nanostructure, producing an atomic diffraction pattern whose envelope carries a direct signature of the atom–surface interaction [1,2]. Ongoing work aims at improving both the accuracy and sensitivity of the C–P force measurement, while exploring its potential to constrain new theories of gravity at short distances.

The goal of the internship is to push this experiment one step further. To make the measurement more sensitive, we need to produce a brighter and better-controlled atomic source. The first part of the internship will therefore focus on developing and optimizing a new cold-atom source based on a spatial light modulator and an optical dipole trap. The student will have an active role in building, aligning and characterizing the setup, and in understanding how the different experimental parameters affect the atomic beam. The improved source will then be used to investigate the interaction of atoms with new nanostructures, including structures with gold surfaces. These measurements will allow us to explore a new range of atom–surface interactions and improve our ability to search for hypothetical short-range forces.

The student will join a team of three permanent researchers and two PhD students, both in their second year, including one PhD student carrying out a co-tutelle with Leibniz University Hannover (Germany). During the internship, the student will also interact with a new PhD student joining the team within the European frame-work. The group works at the interface of quantum optics, cold atoms, nanophysics and precision measurements, providing a stimulating environment in which to develop both experimental skills and scientific independence. A PhD position can follow the internship, with a research project focused on the search for new short-range gravitational interactions and the development of a new generation of multi-nanograting quantum sensors.

[1] J. Lecoffre et al., Phys. Rev. Research **7**, 013232 (2025).

[2] M. Bruneau et al., EPL **151**25001 (2025).



Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: **YES** Soft Matter and Biological Physics: **YES**
Quantum Physics: **YES** Theoretical Physics: **NO**