

PhD scholarship on Casimir Polder force measurement in silicon nanostructures

Laser Physics Laboratory, Université Sorbonne Paris Nord

The PhD student will participate for a fully funded **Marie Skłodowska-Curie Doctoral Candidate** position, within the Horizon Europe Doctoral Network **QUEST – Quantum Electrodynamics with Silicon Nanotechnology**. QUEST brings together leading European universities, research institutes, and innovative companies to advance quantum technologies through silicon nanotechnology. Within this network, you will be one of 15 doctoral candidates working on complementary research projects spanning semiconductor materials, nanofabrication, quantum photonics, quantum electrodynamics, advanced characterization, and theoretical modelling.

This Ph.D. project will take place at the Laser Physics Laboratory in University Sorbonne Paris North in Villetaneuse campus. Apart from the time at LPL, there will be secondments of minimum three months at *Denmark* Technical University, DTU, for nanofabrication in Copenhagen (*Denmark*) and Humboldt-Universität zu Berlin (Germany) for theoretical investigations, LACE Lithography in Bergen (Norway) is our industrial partner for future applications. There will also be regular meetings with the other 14 Ph.D. students in the doctoral network, including 2 training schools and 2 workshops.

As a participant of the project, the PhD student will become part of a team at LPL with experimental expertise in atomic physics and nanotechnology. The activities within the project will benefit from synergies with other projects in the group as well as with other activities at the laboratory. The main supervisor will be Prof. Gabriel Dutier, LPL USPN.

Responsibilities and tasks

Atom surface interactions in vacuum, the Casimir-Polder (CP) potential, have been studied for 30 years struggling with typical distances under 100 nm between atom and surface for a noticeable signal. Transmission gratings crossed by cold metastable Argon recently demonstrate an undeniable better control of both theoretical and experimental parameters for fundamental physics [1-3].

Nevertheless, having the possibility to control the atomic internal state in a region where CP potential is strong enough leads to a completely different category of new phenomena due to the complexity and enhancement of CP for excited atomic states. As examples, one can mention CP control (enhanced, reduced or repulsive, quantum friction) to more exotic quantum entanglement manifestation as collective effects in Casimir Forces [4]. Technical challenge remains to realize a resonant light coupling inside a 2D photonic crystal fibre injected for vacuum constraint. Theoretical investigation will be focused to make the EM evanescent field as homogeneous as possible inside the holes. Experimental constraints impose yet a minimum membrane size of 300 x 100 micrometers.

Scientific repercussions are both fundamental and technological. An achieved control of the diffraction picture through a single nanograting with light leads to the possibility of integrated gravimeters and gyroscopes with a close loop interferometer (3 successive nanogratings) as breakthrough quantum sensors.

Objectives:

- 1- Design and model a minimum 100 x 300 micrometers size of a 2D photonic crystal fiber injected to control the atomic quantum state inside membrane. Low risk.
- 2- Measure diffraction pictures of excited Ar* diffracted through the 2D photonic crystal. Low risk.
- 3- Make a full theoretical analyse of the measured diffraction, especially the CP potential of the first excited state. Low risk.
- 4- Increase the atomic cloud density to reach "collective effects in Casimir Forces". High risk.
- 5- Design and model a "3 gratings closed loop atom interferometer" for inertial quantum sensors. Medium risk.

Expected results:

- 1- Possess the technology for 2D photonic crystal devoted for atomic and molecular diffraction
- 2- Measure Casimir effects of an excited atom in a photonic crystal.
- 3- Pave the way for atomic inertial quantum sensor based on Casimir forces

[1] T. Taillandier-Loize, S. A. Aljunid, F. Correia, N. Fabre, F. Perales, J-M Tualle, J. Baudon, M. Ducloy and G. Dutier, "A simple velocity-tunable pulsed atomic source of slow metastable argon", **J. Phys. D: Appl. Phys.** **49** 135503 (2016)

[2] C. Garcion et al., "Intermediate-range Casimir-Polder interaction probed by high-order slow atom diffraction", **PRL** **127**, 170402 (2021)

[3] J. Lecoffre et al., Measurement of Casimir-Polder interaction for slow atoms through a material grating", **PRR** 7, 013232 (2025)

[4] K. Sinha & P. Meystre, "Collective Effects in Casimir-Polder Forces", **PRL** 121 (2018)

You must have a two-year master's degree (120 ECTS points) or a similar degree with an academic level equivalent to a two-year master's degree.

Qualifications

We are looking for an engineer or physicist with excellent academic records and who has ideally already demonstrated scientific achievements. We are interested in working with candidates who are highly motivated, reliable, self-driven, and have demonstrated during their Master thesis excellence in theoretical physics, electromagnetics, numerical modelling, or quantum optics. Other qualities of the successful candidate:

- Is academically curious and thinks deeply and creatively
- Takes responsibility for the progress and quality of the project.
- Communicates well in both written and spoken English
- Is empathetic and enjoys working with others from diverse backgrounds.

You must have a two-year master's degree (120 ECTS points) or a similar degree with an academic level equivalent to a two-year master's degree. Candidates with a strong background in photonics, quantum optics, laser physics and numerical techniques are preferred. Only candidates with a GPA belonging to the very top can expect to be called for interview.

Due to the **mobility rules** of the Marie Skłodowska-Curie program, **you must not have resided or carried out your main activity (work, studies, etc.) in France for more than 12 months in the 36 months immediately before the recruitment date.**

Approval and Enrolment

The scholarship for the PhD degree is subject to academic approval, and the candidate will be enrolled in one of the general degree programmes at USPN. Assessment of the candidates will be carried out by Senior Researcher Quentin Bouton and Professor Gabriel Dutier.

We offer

LPL is a laser physics laboratory with more than 100 researchers in a multidisciplinary University. We have administrative and technical resources to run experimental research. The proximity with Paris, less than 30 minutes, gives us access to most of the best French laboratories.

Salary and appointment terms

The appointment will be based on the collective agreement with the Doctoral School "Galilée". The period of employment is 3 years.

The **base gross salary** over 36 months is 4.735,81€ per month for living allowance, 710€ maximum per month for mobility allowance and 495€ maximum per month for family allowance.

Further information

Further information may be obtained from Prof. Gabriel Dutier (dutier@univ-paris13.fr).

You can read more about QUEST at <https://quest.dtu.dk>

You can read more about LPL at USPN from <https://www.lpl.univ-paris13.fr/en/>.

LPL - team: <https://www.lpl.univ-paris13.fr/en/research/interferometry-and-optics-for-atoms-oia/>

Application procedure

Your complete files must be submitted to Prof. Gabriel Dutier (dutier@univ-paris13.fr) and Dr Quentin Bouton (quentin.bouton@univ-paris13.fr) before January 2027.

Applications must be submitted as **one PDF file** containing all materials to be given consideration. The file must include:

- A letter motivating the application (cover letter)
- Curriculum vitae
- Grade transcripts and BSc/MSc diploma (in English) including official description of grading scale

You may apply prior to obtaining your master's degree but cannot begin before having received it. Applications received after the deadline will not be considered.

All interested candidates irrespective of age, gender, disability, race, religion or ethnic background are encouraged to apply. The recruitment is taking place following the [European Code of Conduct for Recruitment of Researchers](#), which all candidates are encouraged to study.