ÉCOLE DOCTORALE GALILÉE
Université Sorbonne Paris Nord

Contrat doctoral – ED Galilée

Titre du sujet : Casimir-Polder interaction control of cold atoms and nano devices for fundamental physics

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- Discipline : Physique
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- Domaine de recherche : Physique quantique
- Mots clés : Force de Casimir-Polder, nanoréseaux, figures de diffraction

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Quantum vacuum fluctuations are characterized by the continuous spontaneous creation and annihilation of virtual photons. Notably, macroscopic surfaces influence these fluctuations, resulting in a spatially varying Lamb shift. The gradient of this shift gives rise to an attractive long-range force, known as the Casimir-Polder (C-P) force. This dispersion force, which exhibits a strong dependence on distance at the nanoscale. It thus plays a major role in a multitude of areas of Physics, ranging from atomic physic to fundamental physics such as the 5th force and accurate gravity measurement.

In this context, our team has built a slow atomic beam interacting with a nanograting [1,2]. This jet interacts with a carefully self-engineered nanograting, leading to a diffraction pattern dominated by the C-P force. This unique configuration allows us to study precisely the C-P interaction. The primary goal of the PhD project is to achieve an in-depth understanding of the C-P interaction. To achieve this goal, the successful applicant will take an active role in various aspects of the experiment, including data acquisition, data analysis—which involves quantum electrodynamics calculations and the theoretical modeling of the diffraction patterns—as well as the development of tools for characterizing the atomic source and the installation of an optical dipole trap utilizing Laguerre-Gaussian modes.

The first goal is to tailor the C-P interaction using material geometries and laser light. The second objective is to study eventual modifications of the Newtonian gravitational interaction at short range, where C-P interaction shields such forces. Consequently, this PhD project also encompasses a clean-room component, involving the fabrication and development of novel nanogratings.

[1] C. Garcion et al., *Intermediate-Range Casimir-Polder Interaction Probed by High-Order Slow Atom Diffraction*, Phys. Rev. Lett. **127**, 170402 (2021).
[2] J. Lecoffre et al., *Measurement of Casimir-Polder interaction for slow atoms through a material grating*, Phys. Rev. Research **7**, 013232 (2025).