Masters Internship (stage M2)

Title: **Precision spectroscopy of Casimir-Polder molecule-surface interactions**

Keywords: Casimir-Polder interactions, molecular physics and spectroscopy, sub-wavelength confinement of quantum emitters.

Scientific description:

Interactions between neutral but polarizable objects are essential for the cohesion of matter and play a vital role in our understanding of the electromagnetic properties of matter. One paradigm is the Casimir force between two parallel plates, representing a macroscopic manifestation of quantum fluctuations. Closely related are Casimir-Polder (CP) interactions between a dielectric surface and a quantum object (atom or a molecule) that become important in the nanometric regime.

The SAI group of the LPL has developed selective reflection and nanocell spectroscopy as two major methods for probing Casimir-Polder interactions with *excited* state atoms. Using these techniques, the group has pioneered atom-surface interaction studies focusing on temperature effects [A. Laliotis et al., *Nature Communications,* **5**, 4364 (2014)] that allow probing surface polaritons with atoms [J. C de Aquino Carvalho *et al*., *Phys. Rev. Lett.* **131**, 143801, (2023)].

The group has now turned its attention to performing the first precision CP measurements with molecules. Molecule-surface interactions are of fundamental interest allowing us to study the chirality of quantum vacuum and Casimir-Polder anisotropy. The SAI group has probed molecular gases close to dielectric surfaces via selective reflection [J. Lukusa Mudiayi *et al*. *Phys. Rev. Lett.* **127**, 043201 (2021)] or nanocell spectroscopy [G. Garcia-Arellano *et al*. *Nature Communications,* **15**, 1862 (2024)]. These results allow the study of sub-wavelength confined molecules but have not yet provided a CP measurement.

We are now offering an internship on a new project that aims at probing an HF gas confined inside a nanocell. Our theoretical calculations have revealed HF to be the ideal molecule for CP measurements due to its linear geometry, simplicity and strong transitions at 2,5µm. We are looking for a motivated student to participate in the building of the experiment, detect the first spectroscopic signals and probe Casimir-Polder interactions of HF molecules confined in the nanometric regime. The student will work with H. Mouhanna (postdoc). The intern could also be involved in theoretical calculations of HF-surface interactions in collaboration with the theory group of Stefan Scheel (Universität Rostock, Germany).

Techniques/methods in use: Quantum electrodynamics, atomic and molecular physics, calculations of atomic and molecular spectra, high-resolution laser spectroscopy.
Applicant skills: Experimental skills, good theoretical background in physics and optics.
Duration: from March 2025 till July 2025 (exact dates flexible).
Internship supervisor(s) Athanasios Laliotis (laliotis@univ-paris13.fr) and P. Pedri.
Internship location : Laboratoire de Physique des Lasers, Université Sorbonne Paris Nord
Possibility for a Doctoral thesis: Yes (Ecole Doctorale Galilée)