Titre de la thèse/Thesis title : Metrology of alkali vapors confined at the nanoscale

Laboratoire d'accueil / Host Laboratory : FEMTO-ST

Spécialité du doctorat préparé/Speciality : Engineering sciences

Mots-clefs / Keywords : Atomic spectroscopy, nano-scale confinement, alkali atoms

Descriptif détaillé de la thèse / Job description

The convergence of quantum physics, photonics, and microfabrication technologies has enabled the development of miniature atomic sensors with extraordinary sensitivity and precision. At the core of such instruments—like atomic clocks or magnetometers—lies an atomic vapor confined within a millimeter-scale cell, offering an unmatched balance of volume, power consumption, stability, and sensitivity [1].

A particular type of vapor cell, known as a nanocell, features a significantly reduced spacing between optical windows, providing an elegant way to study light-atom interactions at the sub-wavelength scale [2]. Beyond enabling Doppler-free spectroscopic studies of gases, these nanocells could facilitate the generation of single photons at room temperature using atoms in Rydberg states [3]. While the first nanocells were fabricated about two decades ago, their production relied on artisanal methods like glassblowing, severely limiting their widespread adoption. As a result, few quantitative studies have been conducted, and their metrological characterization remains incomplete.

Using a first prototype of a microfabricated nanocell at FEMTO-ST (https://www.femto-st.fr/en), the candidate will focus on the metrological study of an alkali atomic cloud confined at the sub-wavelength scale. This will involve both the development of a theoretical model describing light-matter interactions at this scale and experimental investigations using prototypes fabricated in the MIMENTO cleanroom facility in Besançon, France. The theory development will be performed in close collaboration with the ICB lab (https://icb.cnrs.fr/) in Dijon, France. The results from comparing theory and experiment will guide the development of a miniature optical frequency reference, with a microfabricated nanocell at its core.

Références bibliographiques / Bibliography

[1] Kitching, J. (2018). Chip-scale atomic devices. *Applied Physics Reviews*, 5(3).

[2] Sargsyan, A., Klinger, E., Leroy, C., Hughes, I. G., Sarkisyan, D., & Adams, C. S. (2019). Selective reflection from a potassium atomic layer with a thickness as small as λ/13. *Journal of Physics B: Atomic, Molecular and Optical Physics*, *52*(19), 195001.

[3] Müller, M. M., Kölle, A., Löw, R., Pfau, T., Calarco, T., & Montangero, S. (2013). Room-temperature Rydberg single-photon source. *Physical Review A—Atomic, Molecular, and Optical Physics*, *87*(5), 053412.

Profil demandé / Applicant profile

The candidate should have an educational background in **Atomic, Molecular and Optical Physics** (AMO).

The candidate should enjoy working in a multidisciplinary environment involving expertise in micro-nano systems, optics, and quantum physics, at the interface between fundamental and applied

physics. Experience in optical modeling, physical system design, and/or instrumentation using Python will be highly valued.

Preferred selection criteria:

- Master's degree (or equivalent) in physics, preferably with a background in atomic, molecular and optical (AMO) physics.
- Previous hands-on experience in **experimental physics** (at minimum in optics; experience with atomic clocks, laser physics or numerical modelling is highly valued).
- Basic knowledge or experience with one or more of the following: laser systems, numerical modelling, instrumentation (Python/Labview).

Personal characteristics:

- Excellent aptitude for **teamwork** in collective experimental efforts.
- Strong personal qualities of **curiosity, intellectual honesty, perseverance, and scientific rigor**.
- Ability to work in an international and interdisciplinary research environment, with good communication skills in English.
- Motivation to acquire expertise in both experimental and theoretical hot atoms atomic physics.

Financement : MESRI Etablissement

Dossier à envoyer pour le **May 20th**
Début du contrat : 1er Octobre 2026
Salaire mensuel brut : 2300€

Direction de la thèse:/ **Thesis Supervisor**
LEPERS Maxence (HDR), maxence.lepers@u-bourgogne.fr

Encadrement de la thèse : **co-directeur(s) et co-encadrant(s)**
BOUDOT Rodolphe (HDR), co-directeur
KLINGER Emmanuel, co-encadrant

Applicants are invited to submit their application to the PhD supervisors.
Application must contain the following documents:
- CV
- Cover letter
- At least 1 reference letter