Master 2: ***International Centre for Fundamental Physics***

INTERNSHIP PROPOSAL

Laboratory name: Laboratoire Aimé Cotton (LAC) / SYstèmes de Référence Temps-Espace (SYRTE)
CNRS identification code: UMR 9025 / UMR 8630
Internship director'surname: Cheinet Patrick / Jérôme Lodewyck
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Internship location:
Laboratoire Aimé cotton, bât 505, Campus d'ORSAY, 91405 Orsay
SYstèmes de Référence Temps-Espace, 77 avenue Denfert-Rochereau, 75014 Paris

Thesis possibility after internship: YES
Funding already obtained for a PhD: YES If YES, which type of funding: ANR

Title : Cold Rydberg atoms for thermometry in optical clocks

Summary: *Rydberg atoms are recognized as new promising high sensitivity sensors to detect electro-magnetic fields [1,2] in large frequency bands from DC up to 1 THz, as already implemented on hot atoms with promising results. Here, we propose to apply this technique to measure the* ***Black-Body Radiation*** *(BBR) field in an optical lattice clock (OLC) [3,4]*

OLCs are ultra-high precision frequency standards based on probing a narrow optical transition in trapped cold atoms [5]. Currently, the BBR-induced frequency shift, in the low 10^{-18}*, remains a major limitation for the accuracy of OLCs. Within a new joint project, LAC and SYRTE aim at implementing Rydberg atom thermometry to allow in-situ temperature measurements within the clock's cold atomic cloud, in order to improve the clock accuracy.*

The objective of the internship, co-hosted by LAC and SYRTE, is to implement a new servo-lock on a Rydberg excitation laser on a spectroscopic signal at LAC and to implement a new laser for Rydberg excitation on a Sr OLC at SYRTE*. These developments will lead to the observation of Rydberg excitation.*

This internship can be prolonged by a PhD, in joint supervision between LAC and SYRTE. Observation of BBR-induced transfers between Rydberg states, and confrontation with theory, will be first realized on a dedicated experiment at LAC. Then, these results will be transposed in a state-of-the art OLC at SYRTE, where the determination of the BBR field with Rydberg atoms will be compared to standard thermometry and a finite element model of the vacuum environment of the clock.

[1] *Atom based RF electric field sensing*, H. Fan *et al.*, J. Phys. B **48**, 202001 (2015)
[2] *Assessment of Rydberg atoms for wideband electric field sensing*, D. H. Meyer *et al.*, J. Phys. B **53**, 034001 (2020)
[3] *Rydberg Spectroscopy in an Optical Lattice: Blackbody Thermometry for Atomic Clock* V. D. Ovsiannikov *et al.*, PRL **107**, 093003 (2011)
[4] *Quantum blackbody thermometry*, E. B. Norrgard et al., NJP **23**, 033037 (2021)
[5] *Optical atomic clocks*, A. D. Ludlow *et al*, Rev. Mod. Phys. 87, 637 (2015)

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

Condensed Matter Physics: (YES) Soft Matter and Biological Physics: NO
Quantum Physics: YES Theoretical Physics: YES