Master 2: *International Centre for Fundamental Physics*

INTERNSHIP PROPOSAL

Laboratory name: SYRTE (Systèmes de Référence Temps-Espace)
CNRS identification code: UMR 8630
Internship director'surname: Sébastien Bize / Manuel Andia
e-mail: sebastien.bize@obspm.fr Phone number: 01 40 51 20 97
e-mail: manuel.andia@obspm.fr Phone number: 01 40 51 21 05
Web page: https://syrte.obspm.fr/spip/science/fop/

Internship location: Observatoire de Paris, 77, avenue Denfert Rochereau, 75014 Paris

Thesis possibility after internship: YES
Funding: to be defined If YES, which type of funding:

Spectral purity transfer between Mercury and Strontium optical lattice atomic clocks

Aim of the proposed internship

Establishing a stable and precise frequency (or time) reference is of paramount importance in several domains, for fundamental physics (tests of special or general relativity, physics beyond the standard model) but also for applications including maintaining the international coordinated time (UTC), realising navigation systems such as Galileo or GPS, or chronometric geodesy [1]. Within that context, our Mercury optical lattice clock [2] benefits from the well-controlled properties of light-atom interactions to allow for the realization of ultra-precise frequency measurements (with relative uncertainties as low as a few 10^{-17}!). These ultra-precise measurements rely on extremely stable oscillators to act as a reference, such as high-finesse Fabry-Perot cavities. Other techniques have also emerged to generate ultra-stable references, such as spectral hole burning [3]. However, most of these oscillators can only be used at a specific wavelength; therefore, there has been growing interest in realising "spectral purity transfer" [4] in order to transfer the exquisite stability properties of an oscillator to a different wavelength. In this context, the SYRTE laboratory organizes spectral purity transfer tests between the Mercury and Strontium 87 optical lattice clocks [5], which operate at very different wavelengths (1062 nm and 698 nm, respectively), through an optical frequency comb.

The successful candidate will get acquainted with the spectral purity transfer technique, and notably the associated experimental setup which contains an intertwined chain of elements (optical and electronic), including servo systems – see Figure above. They will carefully consider and measure each possible source of noise or fluctuations, and implement them into a numerical model. This model will aim to evaluate the impact of the noise sources on the direct comparison between the Mercury and Strontium optical lattice clocks using the spectral purity transfer technique. Finally, the model will help optimise the impact of the new generation of ultra-stable laser systems on the experiment.

[1] S. Bize, C. R. Physique, 20, 153 (2019).
[2] R. Tyumenev et al., New Journal of Physics, 18, 113002 (2016).
[3] M. J. Thorpe et al., Nature Photonics, 5, 688-693 (2011).
[4] D. Nicolodi et al., Nature Photonics, 8, 219-223 (2014).
[5] G. Vallet et al., New Journal of Physics, 19, 083002 (2017).

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: NO