# ***Master 2 Internship  proposal in Quantum Physics***

Laboratory name: SYRTE (SYstèmes de Référence Temps-Espace)
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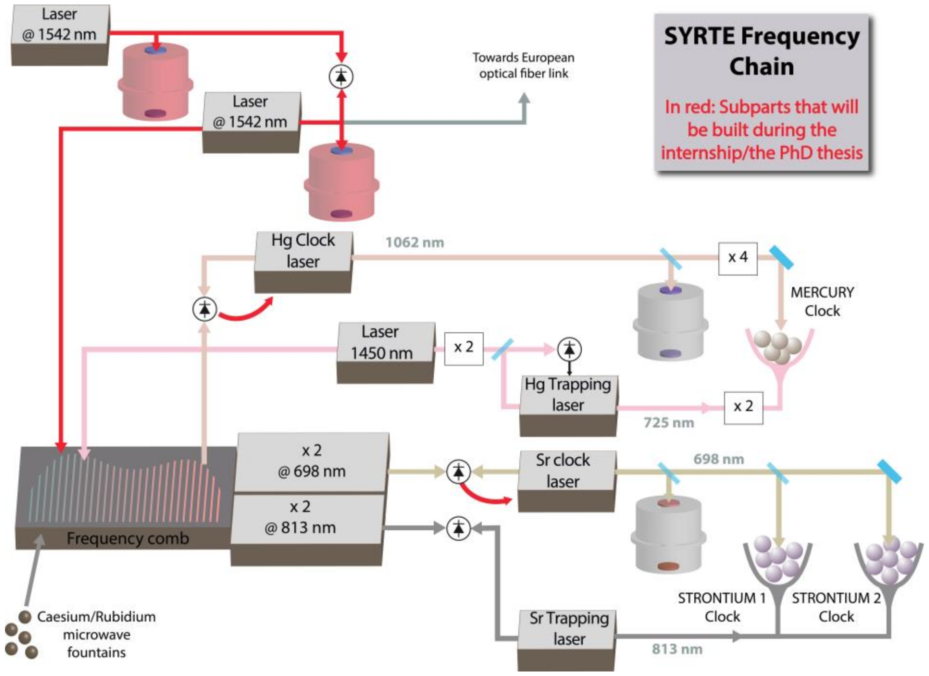
Thesis possibility after internship: YES
Funding: NO

## Transfer of spectral purity to strontium and mercury Optical Lattice Clocks

A new generation of atomic clocks, based on the probing of a narrow (linewidth ≈ 1 mHz) optical transition, has now surpassed the traditional caesium frequency standards. Their principle is to dipole-trap a large (> $10^4$) number of ultracold atoms in an optical lattice and to probe them simultaneously. The internal optical transition that is excited is so narrow that the statistical resolution is limited by the probing laser (linewidth ≈ 1 Hz). The fundamental noise limit imposed by the atomic quantum projection noise has therefore never been reached so far, and despite spectacular performances these clocks are still far away from their limits. This progress raises a considerable interest in the metrology community, but also in quantum physics (collisions, non-destructive interactions, squeezed states …), in general relativity (test of Lorentz invariance, search for dark matter …), or in geophysics (geodesy, mapping of the gravitational potential).

In the scope of the proposed internship, the student will work on a new generation of ultrastable lasers, with the objective of characterizing the performances and transferring the spectral purity to slave lasers by the mean of Optical Frequency Combs. The system is based on a 40-cm long Fabry-Perot cavity equipped with three pairs of high finesse mirrors (698 nm, 1062 nm, 1542 nm), thus allowing to build independent lasers in order to probe atoms in the 3 optical lattice clocks operated at SYRTE (2 strontium clocks, 1 mercury clock). The sensitivity to vibrations will be characterized, and the correlations between the different lasers will be evaluated, in order to design a feedforward strategy to circumvent the deformation modes of the cavity.



The student will join a team of 3 researchers for 3 months, during which he/she will work on the optical and the electronics part of the setup. Skills in Python programming and data analysis are welcome but not necessary. Fluency in English is necessary, basics in French are welcome. The work can be continued in the same laboratory in the form of a PhD thesis, whose topic will be the distribution of spectral purity to Sr and to Hg ultracold atoms. The long-term goal is to reference all the SYRTE clocks to a unique master oscillator, and to use it to produce the very first prototypes of optical timescales. In the context of the upcoming space mission PHARAO-ACES, and frequent international measurement campaigns, the student will be at the heart of the activities of the laboratory.

References:

[1] D. Nicolodi, B. Argence, W. Zhang, R. Le Targat, G. Santarelli, and Y. Le Coq, Nature Photonics 8, p. 219 (2014), "Spectral purity transfer between optical wavelengths at the $10^{-18}$ level"
[2] R. Le Targat et al., Nat. Commun. 4 2109 (2013), "Experimental realization of an optical second with strontium lattice clocks".