# Spécialité de Master « Optique, Matière, Paris »

*Stage de recherche (4 mois minimum, à partir de début mars)*

## Proposition de stage (ne pas dépasser 1 page)

*Date de la proposition : 28.11.17*


**Responsable du stage** / *internship supervisor*:
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**Nom du Laboratoire** Laboratoire Kastler Brossel
Code d'identification : UMR8552 Organisme : ENS/CNRS/UPMC/CdF
Site Internet / *web site*: www.lkb.ens.fr/atomchips/
Adresse / *address:* 24 rue Lhomond, 75005 Paris
Lieu du stage / *internship place*: , 24 rue Lhomond and SYRTE, 77 avenue Denfert-Rochereau


**Titre du stage: Coherence-preserving measurement for improving an atomic clock on a chip**

Quantum physics has advanced to the point where formerly "strange" quantum effects can now be realized in tabletop experiments, stimulating the development of novel quantum-based technologies. One prominent example is the emerging field of quantum sensing, where quan-tum concepts such as entanglement and nondestructive measurement are exploited in mecha-nisms that improve the sensitivity of atomic clocks and interferometers. While these fascinat-ing mechanisms have been the subject of some pioneering proof-of-principle experiments, those experiments did not aim for a metrological level of precision. It is now important to bridge this gap and investigate these mechanisms under metrological conditions, where their relevance to actual atomic sensors can be validated and where new physics may appear that remained undetected at lower precision.

In collaboration with SYRTE, we have developed the Trapped-Atom Clock on a Chip, TACC, which operates close to the projection noise limit and currently has a stability [1] of 5.8x10-13s-1/2. This is in the relevant range for next-generation compact atomic clocks for use in geo-positioning and other mobile applications. Moreover, this clock acts as a test bed for the new physical effects appearing in future atomic clocks and sensors [2]. We have combined our fi-ber Fabry-Perot microcavities with the atom chip of TACC, opening the possibility to produce spin-squeezed states (a particular form of many-body entanglement that can reduces meas-urement noise) and nondestructive measurement. Repeated nondestructive measurements can eliminate the $2\pi$ ambiguity that is inherent to the frequency measurements in all traditional atomic clocks and sensors, thus enabling a "quantum phase lock" that would improve atomic clocks limited by local oscillator noise [3].

The internship has a theoretical and an experimental component. The student will model the cavity-based weak measurement and estimate the systematic shift that it induces on the clock frequency. This will allow identifying the most promising parameter regime for such a meas-urement in our clock cycle. Based on these results, he/she will then be able to test the repeated measurement scheme on the TACC experiment. During the internship, the student will have the opportunity to gain wide-ranging experience in state-of-the-art ultracold atomic physics.


[1] R. Szmuk, V. Dugrain, W. Maineult, J. Reichel and P. Rosenbusch, Phys. Rev. A 92, 012106 (2015).
[2] C. Deutsch et al, Phys. Rev. Lett. 105, 020401 (2010).
[3] R. Kohlhaas, A. Bertoldi, E. Cantin, A. Aspect, A. Landragin, and P. Bouyer, Phys. Rev. X 5, 021011 (2015).


**Ce stage pourra-t-il se prolonger en thèse ?** *Possibility of a PhD* **? : Yes**

**Si oui, financement de thèse envisagé/** *financial support for the PhD***: Yes**

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|---|---|---|---|
| Lumière, Matière, Interactions | **Yes** | Lasers, Optique, Matière | **Yes** |