*Stage de master de physique / Physics Master Internship*

## Proposition de stage/ Internship proposal

*Date de la proposition: 10/11/2022*


**Responsable(s) du stage** / *internship supervisor(s)*:

| Nom / *name* | Prénom/ *first name* |
|---|---|
| Pereira dos Santos | Franck |
| Sidorenkov | Leonid |

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Courriel / *mail*: franck.pereira@obspm.fr, leonid.sidorenkov@obspm.fr

**Nom du Laboratoire** / *laboratory name*: SYRTE

Code d'identification : UMR8630 Organisme : Observatoire de Paris

Site Internet / *web site*: https://syrte.obspm.fr/spip/science/iaci/

Adresse / *address:* 61, avenue de l'Observatoire, 75014 PARIS

Lieu du stage / *internship place*: Paris


**Titre du stage** / *internship title*: **Quantum sensing of the gravity field**


Résumé / *summary*

Our team at SYRTE develops ***inertial sensors*** (gyroscopes, accelerometers…) based on ***atom interferometry*** technics. Benefiting from the maturity of cold atom technology, these instruments rely on manipulation of atomic wave-packets with atom-optics analogs of beam-splitters and mirrors, implemented, for example, via stimulated two-photon Raman transitions. The universality of the atomic test mass and the unprecedented control over atom-light interaction allow for reaching ***record precision and accuracy levels*** in laboratory devices, which is the core of our research activity. An efficient technology transfer in our domain has lead to the recent development of commercial products with applications in geophysics on the field, and of onboard instruments in ships or planes for inertial navigation and geoscience.

Increasing significantly the performances of atomic inertial sensors remains possible, in particular if using ***multi-photon transitions***, which increases the separation between the two arms of the interferometer and thus the sensitivity to inertial forces. We are carrying on a new project of an ***atomic gradiometer*** based on these novel techniques. In this instrument, that measures the Earth gravity gradient, two ultracold atomic clouds will be prepared on ***atom chip traps***, and launched upwards with an accelerated optical lattice. During their free fall, they undergo a sequence of laser pulses that creates two simultaneous interferometers. The detection of the output atomic states of both interferometers gives access to the ***differential phase shift***, which is proportional to the minute difference in the accelerations felt by the two atomic clouds.

The experimental setup is operational close to the state-of-the-art, with validated key subsystems including atom launching in atomic fountains using Bloch elevators, beam-splitters based on low order Bragg diffraction, atomic detection etc. Recent upgrades allow for Earth rotation compensation, accurate control of the differential phase and improved laser beam homogeneity.
The principal task of the internship will be to achieve gravity gradient measurements in a Bragg interferometer with an ***optimized/improved measurement sensitivity***. For that, an intern will have to optimize the efficiency of atom optics beam-splitter and the interferometer contrast, which tend to deteriorate as increasing the momentum transferred to the atoms by the Bragg lasers, because of the finite velocity and position spread of atomic ensemble. He/she will work on improving the control of the frequency and phases of the Bragg lasers, in order to tailor optimized phase profiles for increasing the fidelity of the laser pulses using dedicated ***quantum control methods***.

The internship will include experimental work and, optionally, physical simulation/modelling.
The potential candidate should have a good background in optics and atomic physics.
A particular expertise in semi-classical atom-light interaction is a plus.


**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*: **EDPIF / Own ressources**