Spécialité de Master « Optique, Matière, Paris »

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

Proposition de stage

Date de la proposition : 16/10/2016

Responsable du stage / *internship supervisor*:

Nom / *name*:	Pereira dos Santos	Prénom/ *first name* :	Franck
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Nom du Laboratoire / *laboratory name*: Systèmes de Référence Temps Espace (SYRTE)

Code d'identification : UMR 8630 Organisme : Observatoire de Paris/CNRS/UMPC

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

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

Lieu du stage / *internship place*: 77 avenue Denfert Rochereau 75014 PARIS

Titre du stage / *internship title*: Testing QED and gravity interactions with an ultracold atomic quantum sensor

Résumé / *summary*

The aim of our project is to realize precise measurements of atom surface interactions, in order to test QED and gravity related interactions. We expect to test predictions of underlying theories at distances of order of a µm, and push limits on possible deviations from them. The sensitivity of our atom interferometer sensor will allow improving current limits on tests of gravity at short distances, with a new technique, completely different from "classical" experiments that use macroscopic bodies.

In our experiment, cold atoms are trapped in a vertical lattice, and an atom interferometer is used to measure the force experienced by the atoms [1]. The interferometer is created by putting the atoms in a quantum superposition of wavepackets localized in two neighboring wells thanks to laser pulses, and letting them evolve, before recombining them. The phase difference accumulated by the two partial wavepackets, proportional to the energy difference between the wells, reveals among over quantities, the atom-surface interaction. As a first step, we measured the Bloch frequency, corresponding to the gravitational energy difference between adjacent wells, with a 10^{-7} resolution using a Ramsey type interferometer and atoms far from the surface [2]. This resolution will allow to measure Casimir Polder forces between the atoms and the surface of the mirror with an uncertainty more than one order of magnitude better than state of the art. More recently, we have studied the influence of atomic interactions in a dense ultracold atomic sample onto the coherence time of our interferometer and put into evidence unexpected competition between two synchronization mechanisms, based on spin echo techniques and self-spin rephasing due to the identical spin rotation effect [3]. A good control and understanding of such interactions is a prerequisite for the success of the project.

The aim of this internship consists in realizing force measurements in the vicinity of a mirror placed under vacuum, with ultracold atoms transported close to its surface before being interrogated. The work will focus on optimizing the transport efficiency, the control of the final atoms position, and the loading of the lattice trap. Once loaded in the trap at controlled distances from the surface, first short range force measurements will be carried out.

[1] Q. Beaufils et al., Phys. Rev. Lett. 106, 213002 (2011)
[2] B. Pelle et al., Phys. Rev. A 87, 023601 (2013)
[3] C. Solaro et al., Phys Rev Lett 117, 163003 (2016)

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***: ED**

Lumière, Matière, Interactions	**X**	Lasers, Optique, Matière	**X**