

# Spécialité de Master « Optique, Matière, Plasmas »

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

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

Date de la proposition : 23/10/2013

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### Titre du stage / internship title: *Quantum free fall of an atomic wave packet*

#### Résumé / summary

Quantum reflection is a generic phenomenon for matter waves in a rapidly varying potential. It has been observed in particular for atoms experiencing an attractive Casimir-Polder potential in the vicinity of a solid surface. It is an important problem in the GBAR experiment (*Gravitational Behaviour of Antihydrogen at Rest*) which aims at measuring the free fall acceleration of neutral antihydrogen atoms in the terrestrial gravitational field [1].

A fraction of the cold antihydrogen atoms falling onto the detection plate in the GBAR experiment will be reflected before touching it and this will affect the free fall measurement. Our group is in charge of carrying out accurate evaluations of the potential, in the framework of the scattering approach [2] which has been developed for computing Casimir, Casimir-Polder and van der Waals interactions, as well as the quantum reflection above the detection plate [3].

Up to now, the free fall of the cold antimatter cloud and the quantum reflection has been analyzed within a classical treatment of the center-of-mass motion of antihydrogen atoms. The proposed project aims at extending this analysis to a full quantum treatment of the free fall of the wave packet, using the Wigner function formalism.

The scattering approach and the Wigner function formalism are based on methods in quantum optics. The project implies analytical calculations as well as numerical simulations.

[1] P. Pérez and Y. Sacquin, *Class. Quantum Grav.* **29** (2012) 184008.

[2] A. Lambrecht et al. *New Journal of Physics* **8**, 243 (2006)

[3] G. Dufour, A. Gérardin, R. Guérout, A. Lambrecht, V.V. Nesvizhevsky, S. Reynaud, and A.Yu. Voronin *Phys. Rev. A* **87** 012901 (2013)

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

**Si oui, financement de thèse envisagé/ financial support for the PhD: ED Physique Ile de France**

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