Post Doc Position W/M (2 years)

ULTRA COLD QUANTUM GRAVIMETER

Laboratory : **SYstèmes de Référence Temps-Espace** (SYRTE)
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Our team develops inertial sensors (accelerometers, gyrometers, …) based on atom interferometry technics. The development of this technology is linked to the use of cold atoms and laser beamsplitters, namely two photon transitions and more specifically stimulated Raman transitions. These methods allow now for the development of commercial products with applications in geophysics on the field.

We have developed a state-of-the-art cold atom gravimeter (CAG), based on these techniques. It uses free-falling ^{87}Rb atoms, which experience a sequence of Raman pulses driven by counter-propagating vertical lasers. The atom interferometer phase shift is proportional to *g*, the Earth gravity acceleration that we measure with a sensitivity better than conventional state of the art absolute gravimeters (5.7ng@1s) [1] and more accurately (2n*g*) [2].

Limits have been identified and several improvements will be made to reach the 10^{-10} range both in term of accuracy and stability.

The vacuum chamber will be modified to allow to use a new crossed dipole trap with a 50W laser at 1.1µm. We will take advantage of the reopening of the vacuum chamber to install a rotatable retro-reflexion mirror for the Raman lasers. This will improve our control of the laser alignment and allow to compensate Coriolis acceleration. In order to improve our control on the initial position of the atoms, new MOT collimators will be installed, as well as an innovative fiber splitter system for the control of the powers in each MOT beam.

The applicant will integrate the team and will be in charge of the implementation and optimization of the optical trap.

The ultimate aim is to improve the evaluation of Coriolis acceleration and wavefront distortions effects even further, by performing measurements at very low temperature, and with more atoms. This will require to optimize the evaporation sequence, by increasing the capture volume of the trap using modulation techniques. Yet, a drawback when using dense samples of ultracold atoms, eventually Bose-Einstein condensed, instead of a more dilute laser cooled source, arises from the effect of interatomic interactions, which we will investigate. The obtained uncertainty budget and sensitivity performances will finally be tested during comparisons with absolute and superconducting gravimeters [3].

The applicant will interact and work at SYRTE *(i)* with two permanent researchers, two PhD students already working on the gravimeter and *(ii)* with *h/m* team at LKB. Indeed, the project is a part of a collaborative project between SYRTE and LKB supported by ANR and the regional network SIRTEQ. In particular, tight interactions are foreseen with a joint PhD student between our two teams, who will be in charge of modeling the instruments. This will help to consolidate the accuracy budget to be performed in the frame of this PhD project.

[1] P. Gillot, O. Francis, A. Landragin, F. Pereira dos Santos and S. Merlet, Stability comparison of two absolute gravimeters: optical versus atomic interferometers, *Metrologia* **51** (2014) L15-L17
[2] R. Karcher, A. Imanaliev, S. Merlet and F. Pereira dos Santos, Improving the accuracy of atom interferometers with ultracold atoms, *New J. of Phys*. **20** (2018) 113041
[3] S. Merlet, P. Gillot, B. Cheng, R. Karcher, A. Imanaliev, L. Timmen and F. Pereira dos Santos, Calibration of a superconducting gravimeter with an obsolute atom gravimeter, *J. Geod* **95**, (2021) 62

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