CHINA SCHOLARSHIP COUNCIL

Appel à projets
Campagne 2022
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Title of the research project : High Sensitivity Quantum Gradiometer

Thesis supervisor (HDR) :

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Research Unit

Name : SYRTE

Code *(ex. UMR xxxx)* : UMR 8630

Doctorate School

Thesis supervisor's doctorate school (candidate's future doctoral school) :
ED 564 "Physique en Ile de France"

PhD student currently supervised by the thesis supervisor (number, year of the first inscription) :
2 at 100% (2018, 2020), 2 at 50% (2019,2020)

SORBONNE UNIVERSITÉ

Joint supervisor :

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Research Unit

Name : SYRTE

Code *(ex. UMR xxxx)* : UMR 8630

École doctorale

Joint supervisor's doctorate school : ED 564 Or, if non SU :

PhD student currently supervised by the joint supervisor (number, year of the first inscription) :
2 at 50% (2019,2020)

Joint supervisor :

Name : Surname :

Title :

email :

Professional adress :
(site, dresse, bulding, office…)

Research Unit

Name :

Code *(ex. UMR xxxx)* :

École doctorale

Joint supervisor's doctorate school : Or, if non SU :

PhD student currently supervised by the joint supervisor (number, year of the first inscription) :

Description of the research project (*ENGLISH*)*:*

Context

Our team at SYRTE develops inertial sensors (gyrometers, accelerometers…) based on atom interferometry technics. The development of this technology is linked to the use of cold atoms and laser beamsplitters, easy to implement and efficient, 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, and of onboard instruments in ships or planes for inertial navigation and geoscience. Increasing significantly the performances of such instruments remains possible, in particular if using large multiphoton transitions, which increases the separation between the two arms of the interferometer and thus the sensitivity to inertial forces.

Details of the proposal

We are carrying on a new project of an atomic gradiometer based on these new technics. In this instrument, that measures the Earth gravity gradient, two ultracold atomic clouds will be prepared on atom chip traps, and launched upwards thanks to an accelerated lattice. During their free fall, they undergo a sequence of laser pulses that creates two simultaneous interferometers. The detection of the atomic state at the output of the interferometers allows measuring the difference of the interferometer phase shifts, which is proportional to the difference in the accelerations felt by the two atomic clouds.

The experimental setup is now operational and we have optimized its key subsystems: atom launching in atomic fountains using Bloch elevators, Bragg beamsplitting based on low order Bragg diffraction, and atomic detection.

The tasks of the PhD student will be:

- to implement ultracold atom sources prepared via evaporative cooling methods on atom chips. This will comprise a validation phase of the atom chips produced at the Paris Observatory in a dedicated test setup prior to their installation in the main setup.
- to optimize the measurement sensitivity of the interferometer. For that, the PhD student will have to optimize the beamsplitter efficiency and the interferometer contrast, which tend to decrease when the momentum transferred to the atoms by the Bragg lasers increases. He will work on improving our control of the frequency and phases of the Bragg lasers, so as to be able to tailor optimized phase and intensity profiles in order to increase the fidelity of the laser pulses using quantum control methods.
- to realize gravity gradient measurements using original measurement methods we have recently demonstrated [1,2] and assess the accuracy of the measurements by carefully evaluating the different systematic effects that may bias the interferometer phase
- to carry on long term continuous gravity measurements with the sensor so as to assess its long term stability

References

[1] M. Langlois, R. Caldani, A. Trimeche, S. Merlet, F. Pereira Dos Santos, "Differential phase extraction in dual interferometers exploiting the correlation between classical and quantum sensors", Phys. Rev. A 96, 053624 (2017)
[2] R. Caldani, K. Weng, S. Merlet, F. Pereira dos Santos, "Simultaneous accurate determination of both gravity and its vertical gradient", Phys. Rev. A 99, 033601 (2019)

Profile

A good academic background in atomic physics is necessary.
Experimental skills in experimental physics, especially in optics and electronics are welcome, as well as a previous experience in laser cooling.