Sorbonne Université/ China Scholarship Council program 2020

Thesis proposal

Title of the research project: Development of a new ultra-sensitive cold-atom gyroscope-accelerometer instrument

Keywords: atom interferometry, inertial sensor, cold atoms, test of fundamental physics.

Joint supervision: NO

Joint PhD (cotutelle): NO

Thesis supervisor: Remi Geiger

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Institution: Sorbonne Université

Doctoral school (N°+name): ED564 : «Physique en Île-de-France»

Research laboratory: SYRTE laboratory

Address of the laboratory: …77, avenue Denfert Rochereau, 75014 Paris, France

Name of the laboratory director: Arnaud Landragin

Email address of the laboratory director: arnaud.landragin@obspm.fr

Subject description (2 pages max):

1) Study context

The laboratory and the team. The SYRTE laboratory, located on the Paris Observatory campus, is a joint research unit of CNRS, Sorbonne University and the French National Metrology laboratory (LNE). It is an interdisciplinary laboratory with expertise in time and frequency metrology, atom interferometry, astronomy for the definition of celestial reference frames and history of science, with an internationally renowned reputation in these fields. The

atom interferometry and inertial sensor (IACI) group (about 20 researchers) has developed the field of cold atom inertial sensors for 20 years and is recognized worldwide for its expertise in the field, both on the fundamental and field applications of atom interferometers. Besides pioneering fundamental studies, the team is willing to create links with the industry, one prominent example being the creation in 2011 of the spin-off company *muQuans*. The team has strong international collaborations and is embedded in the Paris-area quantum technology network SIRTEQ.

Context of the project. Cold atom interferometers have reached sensitivity and accuracy levels competing with or outperforming inertial sensors based on different technologies. These sensors have several applications in geophysics, inertial sensing, metrology and fundamental physics. Enlarging their range of applications requires to constantly push further their performances in terms of sensitivity, stability, accuracy, dynamic range, compactness or robustness, ease-of-use, and cost. More than 40 research groups worldwide are actively developing cold-atom inertial sensors for different applications, and investigating techniques to improve their performances. The operation of these sensors is based on atomic interferometry taking advantage of superpositions between quantum states of different momentum of an atom. These superposition states are obtained by means of optical transitions with two (or more) photons communicating momentum to the atom and acting as separating plates and mirrors for the matter waves

2) Details of the proposal

The project will be conducted on the cold atom gyroscope-accelerometer experiment of the IACI group, which has demonstrated several times record performances. The first step in this project will be to use the experiment to perform a test of special relativity (Sagnac effect for matter-waves) in a so-far unexplored range of accuracy, in collaboration with the theory team of the laboratory. The researcher will then gradually work on the development of a new two-axis ultra-cold atom gyroscope experiment that achieves a stability of 1 prad/s for rotation measurements, representing an improvement of two orders of magnitude compared to the current level. This exquisite sensitivity level will allow to perform rotation rate measurements of high interest to the rapidly growing field of rotational seismology. The researcher will also participate to using this instrument for a test of gravitational decoherence models by atomic interferometry.

3) References

M. Altorio et al, arxiv 1912.04793 (2019)

D. Savoie et al, Science Advances, eaau7948 (2018)

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I. Dutta et al, Phys. Rev. Lett. 116, 183003 (2016).

4°) Profile of the Applicant (skills/diploma…)

We are looking for outstanding candidates strongly motivated by challenging experimental physics projects. The applicant should have skills in experimental physics and in particular in optics and laser science, electronics, and instrumentation. A good knowledge of atomic physics is preferable. A Master degree or equivalent (e.g. diploma in electrical engineering or photonics engineering) is mandatory.

Contacts:

Thesis supervisor

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