Application for a Master 1 or Master 2 internship with possibility to pursue a PhD thesis

M2 or M1 internship (3 to 6 months, starting winter or spring 2026):

A continuous cold-atom interferometer to achieve quantum noise detection limit in inertial force measurements

Laboratory: Laboratoire Temps Espace - Observatoire de Paris, 77 avenue Denfert Rochereau, Paris 14, France

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Context: Cold atom inertial sensors have many applications in fundamental physics (testing the laws of gravitation, gravitational astronomy), geosciences (measuring the Earth's gravity field or rotation) and inertial navigation [1]. The operation of these sensors is based on atomic interferometry, taking advantage of superpositions between quantum states of different momentum in an atom, generated by optical transitions with two (or more) photons in order to realize accurate sensors. LTE (formerly SYRTE) is a pioneering laboratory in this field, recognized worldwide for its expertise in the metrology of these quantum sensors [2,3], their use in various applications, and their technological transfer.

The objective of this master's project will be to develop continuous measurements using cold atom interferometers in order to improve their sensitivity while maintaining their accuracy. One of the limitations of cold atom inertial sensors is the inherently sequential nature of the measurement, which leads to a loss of information between successive measurements and aliasing effect of the inertial signal. The first developments in continuous operation have already demonstrated record performance for rotation measurements [4], but need to be modified to realise their full potential for rotation measurements, but also acceleration measurements. Ultimately, these sensors must reach the detection limit, intrinsically linked to quantum projection noise. This method is very general in atomic quantum sensors and can also be applied to different schemes of interferometer, atomic clocks...

Master thesis work: In order to realise this continuous measurement, we must use a sequence whose cycle time is twice as short as the interrogation time (at least two atomic samples in the interferometer at any given time). To achieve this regime, certain modifications must be made to the existing experiment (in particular to the Raman lasers used to manipulate the atomic wave packets) in order to simultaneously realise atomic beam splitters and mirror for three independent atomic samples. This involves the use of an electro-optical modulator, modification of the phase-locked loop between the Raman lasers, and modification of the amplification of the laser beams using tapered optical amplifiers. The preparation and detection of atomic samples must also be modified, as must the timing sequence, to ensure that the light emitted by the atoms during these stages does not disturb the atoms inside the interferometer.

References: [1] R. Geiger et al, AVS Quantum Sci. 2, 024702 (2020) ; [2] R. Gautier et al, Science Advances (2022) ; [3] L. Sidorenkov et al, Phys. Rev. Lett. 125, 213201 (2020) ; [4] D. Savoie et al, Science Advances, eaau7948 (2018);

The subject will be adapted to the M1 or M2 level and the duration of the internship.
Possibility to pursue a PhD after the internship: YES.
Key words: atom interferometry, quantum sensor, cold atoms.
Required skills: optics and lasers, instrumentation, atomic physics, basis of Python programming for experimental control and data analysis; ability to work in a team.