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

M2 internship (6 months, starting in March 2020): Test of special relativity through a high-accuracy measurement of the Sagnac effect for matter-waves

Doctoral thesis (3 years, starting in October 2020): Development of a new ultra-sensitive cold-atom gyroscope-accelerometer instrument

Laboratory : SYRTE - Observatoire de Paris, 77 avenue Denfert Rochereau, 75014 Paris, France

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Asbtract: Cold-atom inertial sensors offer many applications in fundamental physics (tests of the laws of gravitation, gravitational astronomy), geosciences (measurements of the gravity field or of Earth rotation) and inertial navigation (inertial units). 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. SYRTE is a pioneer laboratory of the field, recognized worldwide for its expertise in the metrology of these quantum sensors, their use for different applications, and their technological transfer.

The aim of this internship is to continue the development of the SYRTE cold-atom gyroscope-accelerometer experiment and to use it to conduct a test of the Sagnac effect (appearance of a phase shift in an interferometer with a physical area under rotation) for matter waves, with unmatched accuracy (2 orders of magnitude better than previous experiments). The internship will combine aspects of instrumentation to improve the stability of the gyroscope and modeling aspects to understand the systematic effects of the measurement (fine understanding of the light-matter interaction responsible for the creation of the interferometer). The adequacy between theoretical calculations and experimental data will be put to the test during the internship.

In the case of a PhD, you will work on the development of a new double-axis ultra-cold atom gyroscope-accelerometer experiment that achieves a stability of 10^{-12} rad / s for rotation measurements, representing an improvement of two orders of magnitude compared to the current level. Achieving such a level of sensitivity would, among other things, constitute a revolution in the field of seismology, offering the possibility of knowing the local velocity of the seismic waves and their direction of propagation. The use of this instrument for fundamental physics is also studied; you will work in particular on a test of gravitational decoherence models by atomic interferometry (decoherence of a state superposition by coupling to a local gravity field), in connection with the theoreticians of the SYRTE team and an international team.

References : M. Altorio et al, arxiv 1912.04793 (2019) ; D. Savoie et al, Science Advances, eaau7948 (2018); I. Dutta et al, Phys. Rev. Lett. 116, 183003 (2016).

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

Required skills: optics and lasers, instrumentation, atomic physics, data analysis; ability to work in a team.

Funding: Both master 2 and PhD programs have solid funding (project from the French Research Agency).