Proposition de stage/ Internship proposal

Date de la proposition : 03/10/2023

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Code d'identification : UMR 8630 Organisme : Observatoire de Paris
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Lieu du stage / *internship place*: Paris

Titre du stage / *internship title*:

Delta Kick Squeezing for Atom Interferometry beyond the Standard Quantum Limit

Résumé / *summary*

Our team at SYRTE develops inertial sensors (gyrometers, accelerometers…) based on atom interferometry technics. The development of these instruments benefits from the maturity of ultracold atom technology and the advantage of light beamsplitters, easy to implement and efficient, namely two photon transitions and more specifically stimulated Raman transitions. If 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 by using advanced quantum metrology methods to surpass the standard quantum limit.

The aim of this intership is the implementation of the "Delta-Kick squeezing" (DKS) technique, recently proposed by Robin Corgier, currently a postdoctoral fellow at SYRTE, and his collaborators. This DKS rely on the engineering of atom atom interactions in a BEC in free fall. Such interactions induce strong correlations between the atoms, and lead to squeezing in the population difference between the two interferometer paths, and eventually to phase sensitivity below the standard quantum limit.

The intern will work on implementing this method in a free-falling atom interferometer, based on the use of Raman light beamsplitters and ultra-cold atoms produced by evaporative cooling. The work, essentially experimental in nature, will first consist in optimizing the preparation sequence of ultra-cold atoms, to obtain Bose Einstein condensates in a robust and efficient way, and in optimizing the detection method of the two output ports of the interferometer. The intern will then demonstrate the possibility of realizing strongly spin-squeezed states through atomic lensing methods based on pulse sequences realized with highly detuned high power laser beams. Finally, he or she will study the impact of the use of these quantum states in an interferometer on the sensitivity of measurements. He or she will conduct the experimental studies and participate in the analysis of the results. He or she will have extensive theoretical support for the modeling of the experiment, the optimization of the measurement sequence and for the analysis of the results.