INTERNSHIP PROPOSAL

Laboratory name: SYRTE
CNRS identification code: UMR8630
Internship director' surname: Pereira dos Santos / Sidorenkov
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Internship location: Paris
Thesis possibility after internship: YES
Funding: YES If YES, which type of funding: Group proper resources

Atom chip technology for quantum gravity sensing

Research context: Our team at SYRTE develops ***inertial sensors*** (gyroscopes, accelerometers…) based on ***atom interferometry*** technics. Benefiting from the maturity of cold atom technology, these instruments rely on manipulation of atomic wave-packets with atom-optics analogs of beam-splitters and mirrors, implemented, for example, via stimulated two-photon transitions. The universality of the atomic test mass and the unprecedented control over atom-light interaction allow for reaching ***record precision and accuracy levels*** in laboratory devices, which is the core of our research activity. An efficient technology transfer in our domain has led to the recent development of commercial products with applications in geophysics on the field, and of onboard instruments in ships or planes for inertial navigation and geoscience.

Project: A significant improvement in the performances of atomic inertial sensors is linked to the development of novel sensor architectures and habilitating technologies. We are carrying on a new project of an ***atomic gradiometer*** sensing the vertical gravity gradient of the Earth. Here, two ultra-cold atomic clouds will be prepared on ***atom chip traps***, and launched upwards with an accelerated optical lattice. During their free fall, they undergo a sequence of laser pulses that creates two simultaneous interferometers. The detection of the output atomic states of both interferometers gives access to the ***differential phase shift*** proportional to the minute acceleration variation felt by the distant atomic clouds. Such gradient signal is ***free of common-mode vibrational and laser noise***, which makes our sensor a perfect platform for exploring novel techniques. This includes, in particular, using (i) ***multi-photon transitions***, which increases the separation between the two arms of the interferometer and thus the sensitivity to inertial forces; (ii) ***quantum metrology*** protocols for reaching atomic sub-shot noise performance.

Internship: The main experimental setup is operational close to the state-of-the-art, with validated key subsystems including cold (~1μK) atom preparation in a MOT, followed by interferometric cycle, and atomic state detection. In order to constrain the systematic effects caused by the finite velocity and position spread of atomic ensemble, we then employ a narrow-band velocity selection pulse that out-couples a small fraction of "colder" atoms useful for interferometric cycle. This atom loss, in turn, limits the attainable quantum-projection noise restraining the gradiometer sensitivity. The goal of the internship will be to ***test and optimize the functionality of the atom-chip traps*** for obtaining larger samples of ***ultra-cold (~100 nK) atoms*** within comparable preparation times of ~1s. An intern will use an auxiliary tabletop apparatus with an atom chip and associated hardware, to obtain a MOT and perform a ***rapid evaporative cooling (potentially towards BEC)*** in the steep magnetic potential generated by the micro-fabricated electric wire patterns on the atom chip. The results of extensive tests should reveal the optimal source preparation strategy and demonstrate an ***improved performance of the gradiometer*** (it has a similar atom chip) ***with ultra-cold thermal atoms***. The internship will include experimental work and physical simulation / modelling. The potential candidate should have a good background in optics and atomic physics. A particular expertise in quantum gases is a plus.

Condensed Matter Physics: YES Soft Matter and Biological Physics: NO
Quantum Physics: YES Theoretical Physics: NO