INTERNSHIP PROPOSAL

Laboratory name: SYRTE
CNRS identification code: UMR8630
Internship director' surname: Pereira dos Santos / Sidorenkov
e-mail: franck.pereira@obspm.fr / leonid.sidorenkov@obspm.fr Phone number: 0140512386
Web page: https://syrte.obspm.fr/spip/science/iaci/

Internship location: Paris
Thesis possibility after internship: YES
Funding: YES If YES, which type of funding: Group proper resources

Quantum sensing of the gravity field

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 experimental setup is operational close to the state-of-the-art, with validated key subsystems including cold atom preparation, launching in the atomic fountain geometry using Bloch elevators, beam-splitters based on low order Bragg diffraction, atomic detection etc. Recent upgrades allow for Earth rotation compensation and accurate control of the differential laser phase. The principal task of the internship will be to achieve gravity gradient measurements in a Bragg interferometer with an ***optimized/improved measurement sensitivity***. For that, an intern will have to optimize the efficiency of atom optics beam-splitter and the interferometer contrast, which tend to deteriorate as increasing the momentum transferred to the atoms by the Bragg lasers, because of the finite velocity and position spread of atomic ensemble. He/she will work on ***upgrading the Bragg laser system***, improving the control of the frequency, phase and amplitude of the Bragg pulses, and laser beam homogeneity (top-shape collimators). Using dedicated ***quantum control methods***, he/she will tailor the optimization of pulse profiles for increasing their fidelities and overall interferometric contrast. 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 semi-classical atom-light interaction is a plus.

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