INTERNSHIP PROPOSAL

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Thesis possibility after internship: YES
Funding: No

Bringing a cold-atom interferometer to the quantum noise detection limit

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 (inertial navigation systems). 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. SYRTE is a pioneering laboratory in this field, recognized worldwide for its expertise in the metrology of these quantum sensors, their use in various applications, and their technological transfer. To broaden their range of applications, it is necessary to constantly push back their performance in terms of sensitivity, stability, precision, dynamic range, compactness or robustness, ease of use and cost.
The aim of this Master project will be to study and develop SYRTE's cold atom gyroscope, in order to improve its performance to a stability of 10 prad/s for rotation measurements, which represents an improvement of more than an order of magnitude compared with the current state of the art. It will use the new methods to improve its sensitivity by reducing noise contributions in order to reach the interferometer's detection limit, which is intrinsically linked to quantum projection noise.

Master thesis work: In order to improve our record-breaking performance to reach the standard quantum limit, we need a measurement system with no dead time. Dead time between consecutive measurements leads to a loss of information that prevents this fundamental limit from being reached. In contrast, successive joint measurements without dead time allow the sampling noise of the inertial signal and the phase noise of the laser to average out with time, rapidly becoming negligible compared with the detection noise and the quantum projection noise, which only average out as the square root of time. In order to take full advantage of this method with our four-pulse interferometer, we need in practice to use a sequence whose cycle time is twice as small as the interrogation time (two atomic samples in the interferometer at any one time). Obtaining this regime requires some modifications to the existing experiment, in particular to the Raman lasers used to manipulate the atomic wave packet, but also to the preparation and the detection of the atomic samples. The improvement will be studied by comparison and correlation with a state-of-the-art fibre-optic gyroscope. This method is very general and could also be applied to more common three-pulse interferometers such as accelerometers and gravimeters.

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

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