Master thesis and PhD application

Tests of Fundamental Physics by Atom Interferometry

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Abstract : Cold-atom inertial sensors offer several applications in fundamental physics (tests of gravitation, gravitational wave astronomy), geosciences (measurements of the Earth gravity field or rotation rate), inertial navigation, and metrology (measurement of fundamental constants). This Master thesis has the objective to develop the gyroscope-accelerometer experiment of the SYRTE laboratory, and to use it to perform a test of Lorentz invariance by atom interferometry. The Master thesis can be followed by a PhD.

The Master work will be mainly experimental on the cold-atom gyroscope-accelerometer of SYRTE, which represents the state-of-the-art for cold-atom inertial sensors. The experiment relies on atom interferometry which uses superposition of different quantum states of a Cesium atom. These superpositions are obtained by optical transitions involving two (or more) photons which transfer momentum to the atom and play the role of beams splitters and mirrors for the matter-waves.

During the Master thesis, you will participate to a test of Lorentz invariance with the cold atom accelerometer. This invariance is one of the pillar of relativity and states that the physical laws, and therefore the observable phenomena, do not depend on the orientation of the reference frame in which an experiment is performed with respect to the Universe, nor on its velocity with respect to a possible absolute reference frame. Lorentz invariance is predicted to be violated in several theories aiming at unifying the fundamental interactions.

If you continue as a PhD student, you will work on the development of a two-axis cold-atom gyroscope-accelerometer which can feature a rotation rate stability of $10^{-11}\ rad.s^{-1}$, which represents one order of magnitude improvement with respect to the present stability level. Such stability will allow studies in geophysics through precision measurements of the Earth rotation rate, and in fundamental physics. You will carry out such studies. In particular, you will work on a test of gravitational decoherence models by atom interferometry (decoherence of a quantum superposition by its coupling to a local gravitation field), in link with the theory team of SYRTE and with an international team.

Key words : atom interferometry, inertial sensor, cold atoms, Lorentz invariance, gravitational decoherence.