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Accurate rotation rate measurement with a cold atom gyroscope

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As soon as the concept of matter-wave duality rose from the early development of quantum mechanics, the possibility of creating atomic interferometers has been studied. Measurement of rotation rates through the Sagnac effect, well known in optics, became possible with atomic waves around 1990. Nowadays, cold-atom gyroscopes can reach high sensitivities competing with optical Sagnac interferometers, like fiber gyroscopes. Cold-atom inertial sensors feature promising
applications in navigation, geoscience and for tests of fundamental physics.
In our experiment, we laser-cool cesium atoms to a temperature of 2.0 μK and launch
them vertically at a velocity of 5 m$\cdot$s^{-1}. Light pulse atom interferometry with counter propagating
Raman transitions is used to create an interferometer with a Sagnac area of 11 cm^2. We then detect the internal state of the atoms at the end of the interferometer using fluorescence detection.
The SYRTE cold atom gyroscope represent the state-of-the-art of atomic gyroscopes with
a long term stability[1] of 3$\cdot$10^{-10} rad$\cdot$s-1. The gyroscope has been used to test new methods to reach
better sensitivity, like the possibility to work without dead time by interrogating three atomic
clouds simultaneously[2], allowing us to reach a sampling rate of 3.75Hz. To reach such stability,
we need to understand and minimize the systematic effects, the main one coming from the coupling of an imperfect launch velocity and a misalignment between the two Raman beams used to perform the interferometer[3].
In this talk I will present our work on the evaluation of the scale factor of the gyroscope and how
it allows us to test the validity of the Sagnac effect for matter waves. The phase shift induced by
Earth rotation depends on the angle between the oriented Sagnac area of the interferometer and
the geographic north. By rotating our apparatus, we are able to vary this angle, and therefore
modulate the phase shift. This allows us to perform a test of the Sagnac effect with a relative accuracy of 2$\cdot$10^{-4}, which represents an improvement of a factor 100 compared to previous matter
wave experiments.

1 "Interleaved Atom Interferometry for High Sensitivity Inertial Measurements"D. Savoie, M. Altorio, B. Fang, L.
A. Sidorenkov, R. Geiger, A. Landragin, Science Advances, Vol. 4, no. 12, eaau7948 (2018)
2 "Continuous Cold-Atom Inertial Sensor with 1 nrad/sec Rotation Stability"I. Dutta, D. Savoie, B. Fang, B. Venon,
C. L. Garrido Alzar, R. Geiger, and A. Landragin, Phys. Rev. Lett. 116, 183003 (2016)
3 "Accurate trajectory alignment in cold-atom interferometers with separated laser beams"M. Altorio, L. A. Sidorenkov, R. Gautier, D. Savoie, A. Landragin and R. Geiger, Phys. Rev. A 101, 033606 (2020)

Presenter: GAUTIER, Romain (SYRTE)