

## Accurate rotation rate measurement with a cold atom gyroscope

*jeudi 18 mars 2021 11:00 (1 heure)*

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  $2.0 \mu\text{K}$  and launch them vertically at a velocity of  $5 \text{ m}\cdot\text{s}^{-1}$ . Light pulse atom interferometry with counter propagating Raman transitions is used to create an interferometer with a Sagnac area of  $11 \text{ cm}^2$ . 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<sup>1</sup> of  $3\cdot 10^{-10} \text{ rad}\cdot\text{s}^{-1}$ . 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<sup>2</sup>, allowing us to reach a sampling rate of  $3.75\text{Hz}$ . 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<sup>3</sup>.

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)

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