Improving an Atomic Clock on a Chip via Spin-squeezing

Jose Alberto de la Paz[1], Meng-Zi Huang[2], Étienne Chaumeton[3], Alice Sinatra[3], Jakob Reichel[3], Carlos L. Garrido Alzar[1]

[1]SYRTE, CNRS, Observatoire de Paris, Université PSL, Sorbonne Université, LNE, 61 avenue de l'Observatoire, 75014 Paris, France
[2]Institute for quantum electronics, ETH Zurich, Switzerland
[3]Laboratoire Kastler Brossel, ENS-Université PSL, CNRS, Sorbonne Université, Collège de France, 24 rue Lhomond, 75005 Paris, France

Email: alberto.delapaz@obspm.fr

Atom sensors are highly sensitive devices used in time and frequency standards, inertial sensing, and precision fundamental physics measurements. Nowadays, they have been developed with performances limited by the standard quantum limit (SQL). This limit arises from the uncorrelated behaviour of the atoms. However, we can overcome this limit via the generation of entanglement between the atoms. Proof of principle entanglement generation with atoms can be accomplished via different protocols, but this has very seldom been done in metrology-grade devices. Here, we present the use of a cavity quantum electrodynamics (cQED) platform on a microwave atomic clock on a chip to create spin squeezing. Our study will investigate a critical systematic effect in atom-trapped clocks. Namely, the influence of interaction-induced spin dynamics in long-interrogation time scales typical in atomic clocks and atom interferometers. The stability of this clock is confirmed by a fractional frequency stability of 6×10^{-13} at 1 s. In addition, we will introduce clock protocols that consider this new limiting phenomenon in high-sensitivity atom interferometers.