Towards a compact and high-long-term stability CPT-based cesium cell atomic clock

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Microwave vapor cell clocks, with their compact design and low power consumption, excel for navigation and communication applications[1]. Notably, coherent population trapping (CPT) frequency standards achieve fractional frequency stability levels at 1 s in the low 10^{-13} range[2,3].

The implementation of advanced interrogation sequences, such as symmetrical auto-balanced Ramsey (SABR) spectroscopy, has proven to be efficient for reducing the sensitivity to light-shift effects in CPT clocks, leading to the demonstration of Allan deviation results entering the 10^{-15} range after a few hundreds of seconds[4]. Nevertheless, these performances were obtained on restricted acquisition durations, keeping unexplored the long-term stability potential for this clock architecture[4.]

At FEMTO-ST, we work on the development of a high-performance Cs cell clock. The latter combines the optimized push-pull optical pumping (PPOP) scheme and a SABR sequence. Its short-term stability is $2\text{x}10^{-13}$ at 1 s. In this work, the sensitivity of the clock frequency to the variations of numerous experimental parameters (laser power, laser frequency, microwave power, cell temperature, magnetic field, translation and rotation of some wave plates and optical elements, etc.) has been investigated. Main reported contributions at 1 day are the temperature of some passive components in the Michelson system (4.1×10^{-14}), the microwave power (8.5×10^{-15}) and the static magnetic field ($2\text{x}10^{-15}$). Other contributions are measured below 10^{-15}. Studies are still in-progress as an unknown mechanism, which remains to be identified, currently limits the clock Allan deviation for $\tau > 200$ s.

In parallel to these metrological studies, we work on the design, development and characterization of a more compact CPT clock setup. Fig. 1 shows a photograph of this setup. This effort holds significance not only for meeting industrial needs but also for reducing the detrimental influence on the clock frequency of environmental parameters perturbation.

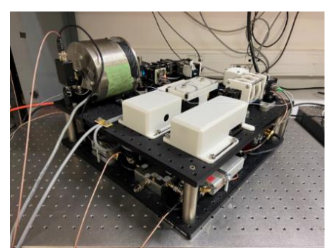

Fig. 1: Photograph of the under-progress compact CPT clock setup development.

Latest results on both setups will be presented at the conference.

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