

Cesium Microcell Optical Reference at 459 nm With a Frequency Stability in the Low 10^{-13} Range at 1 s

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Microfabricated (MEMS) alkali vapor cells are at the core of high precision integrated atomic quantum sensors and devices [1], such as microwave and optical clocks, or magnetometers. The first chip-scale atomic device was a microwave atomic clock based on coherent population trapping [2]. It has offered in its industrial and commercialized version an ultra-low size-power-instability budget, impacting a plethora of industrial and scientific applications. Nevertheless, the short-term stability of these clocks is usually limited at about 10^{-10} at 1 s.

Hot vapor MEMS-based optical frequency standards constitute a new generation of miniaturized clocks, with enhanced stability. These references keep the benefit of using wafer-scalable and mass-producible vapor cells while preventing ultra-high vacuum technologies and laser cooling. Among the transitions explored, the $6S_{1/2} - 7P_{1/2}$ transition at 459 nm of Cs atoms was used to demonstrate an optical reference with a stability of 2.1×10^{-13} at 1 s and averaging down to a few 10^{-14} [3]. However, this reference was based on a 5 cm-long glass-blown cell and an electro-optic modulator, not compliant with the advent of a fully-miniaturized and low-power optical clock.

In a previous work [4], we have characterized the sub-Doppler resonances detected in a microfabricated cell by probing, with saturated absorption spectroscopy (SAS), the Cs atom $6S_{1/2} - 7P_{1/2}$ transition at 459 nm. The impact of the laser intensity and cell temperature on the sub-Doppler resonance was experimentally investigated. Optimal values were identified for the development of a microcell-stabilized frequency reference at 459 nm.

In this work, we describe the implementation and short-term frequency stability characterization of external-cavity diode lasers stabilized onto the $6S_{1/2} - 7P_{1/2}$ transition of Cs atom at 459 nm, using a microfabricated vapor cell, in a basic retroreflected configuration saturated absorption spectroscopy setup (see Fig. 1). The laser beatnote obtained between two quasi-identical systems demonstrates an instability of 2.5×10^{-13} at 1s, currently limited by the laser FM noise through the FM-AM conversion process and the intermodulation effect, and in good agreement with the noise budget [5]. The stability averages down at the level of 4×10^{-14} at 100 s. Sensitivity coefficients of the laser beatnote frequency to the laser power at the cell input and cell temperature variations are currently being measured. The latest results will be presented at the conference.

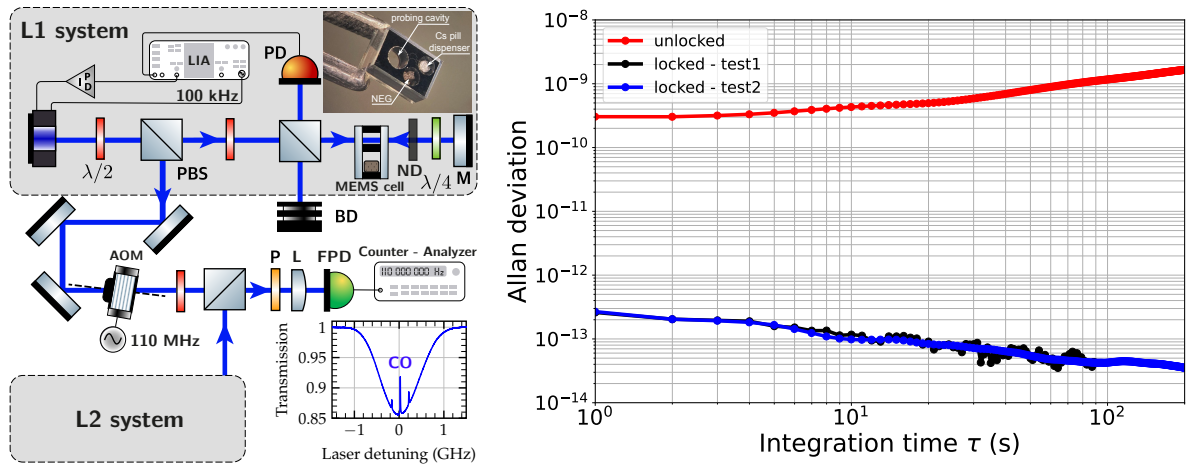


Fig. 1: Two lasers, tuned at 459 nm, are stabilized onto a Cs vapor microfabricated cell in a simple SAS configuration. The frequency of the first laser is shifted by 110 MHz using an acousto-optic modulator to create a beatnote between the two quasi-identical systems. When both lasers are locked, the beatnote demonstrates an instability of 2.5×10^{-13} at 1 s and 4×10^{-14} at 100 s.

References

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