Saturated absorption spectroscopy of the Cs atom $6S_{1/2} \rightarrow 7P_{1/2}$ transition at 459 nm in a microfabricated vapor cell

Emmanuel Klinger[1], Andrei Mursa[1], Carlos M. Rivera-Aguilar[1], Rémy Vicarini[1], Nicolas Passilly[1] and R. Boudot[1]

[1] FEMTO-ST–CNRS, Université de Franche-Comté, ENSMM, Besançon, France

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 $6S_{1/2} \rightarrow 7P_{1/2}$ near-UV transition of Cs atom 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, not compliant with the advent of a fully-miniaturized and low-power optical clock.

In this work [4], we present the characterization of sub-Doppler resonances detected in a microfabricated cell by probing, in a simple saturated absorption configuration, the Cs atom $6S_{1/2} \rightarrow 7P_{1/2}$ transition at 459 nm. The impact of the laser intensity and cell temperature on the sub-Doppler resonance is experimentally investigated. Optimal values are identified for the development of a near-UV microcell-stabilized frequency reference. Detection noise measurements are also reported, predicting a short-term stability in the 10^{-13} range at 1 s. Tests of cells with embedded getters are under progress for improved purity of the cell inner atmosphere and narrowing of the resonance.

[1] J. Kitching, Appl. Phys. Rev. **5**, 031302 (2018).
[2] S. Knappe, V. Shah, P.D.D. Schwindt, L. Hollberg, J. Kitching, L-A. Liew and J. Moreland, Appl. Phys. Lett. **85**, 1460 (2004).
[3] J. Miao, T. Shi, J. Zhang and J. Chen, Phys. Rev. Appl. **18**, 024034 (2022).
[4] E. Klinger, A. Mursa, C. M. Rivera-Aguilar, R. Vicarini, N. Passilly, and R. Boudot, Opt. Lett. **49** (2024).
[5] R. Boudot, J. P. McGilligan, K. R. Moore, V. Maurice, G. D. Martinez, A. Hansen, E. de Clercq and J. Kitching, Sci. Rep. **10**, 16590 (2020).