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

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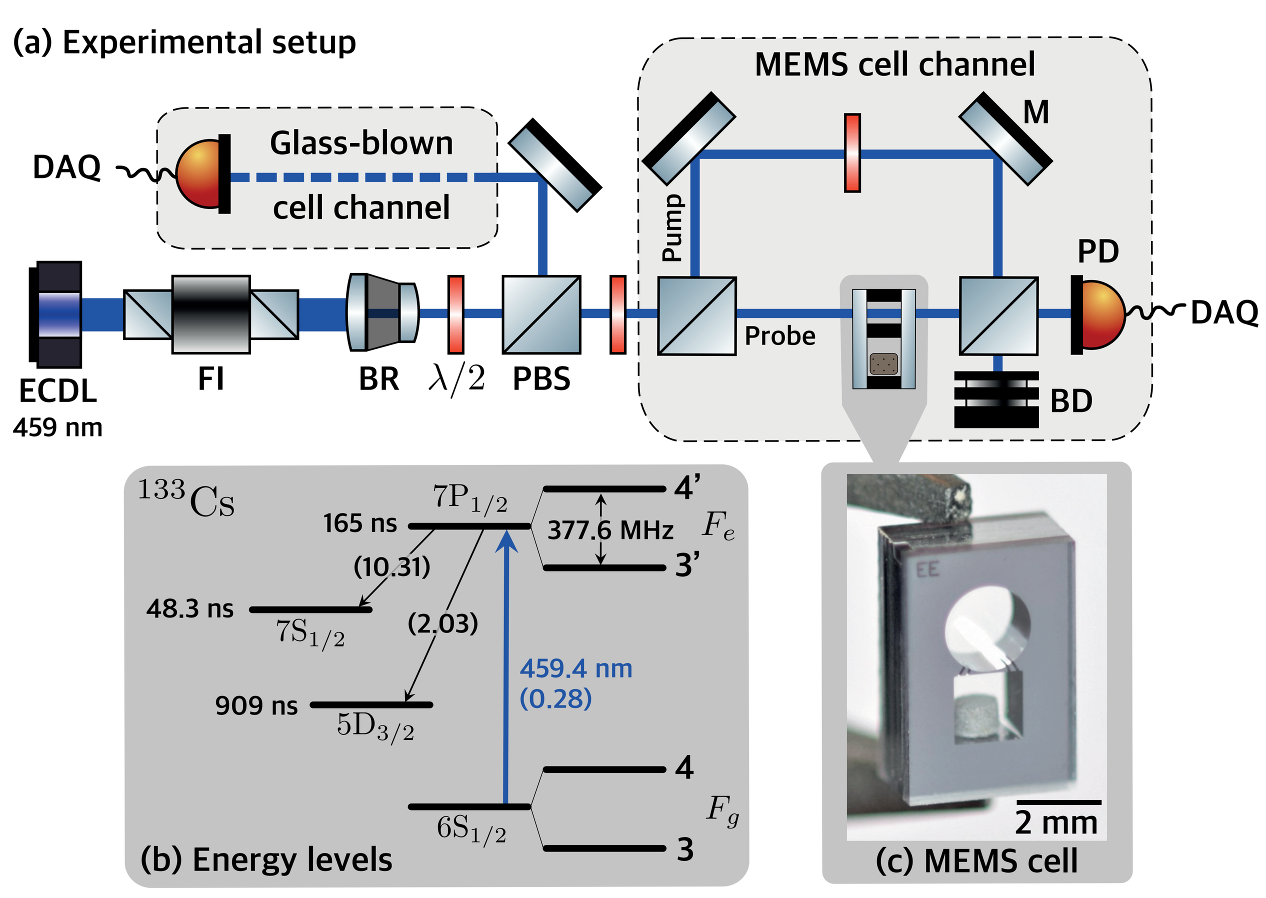
Abstract

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 [2].

Hot vapor MEMS-based optical frequency standards constitute a new generation of miniaturized clocks, with enhanced stability [3,4]. These references keep the benefit of using wafer-scalable and mass-producible vapor cells while preventing the use of ultra-high vacuum technologies and laser cooling.

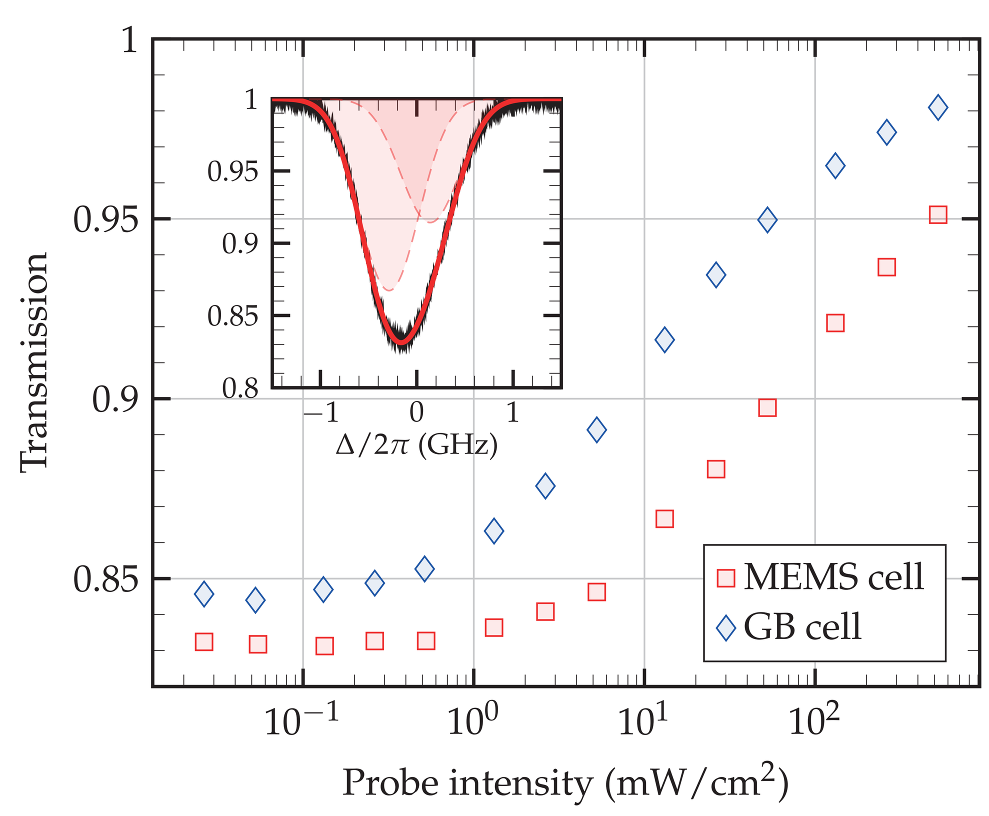
Here, we present the characterization of sub-Doppler resonances detected in a MEMS cell by probing the Cs atom $6S_{1/2} - 7P_{1/2}$ transition at 459 nm [5] with saturated absorption spectroscopy (SAS). Optimal values of the laser intensity and cell temperature are identified for the development of a near-UV microcell-stabilized frequency reference. Beating two identical systems, preliminary results indicate a beatnote short-term stability in the low 10^{-13} range at 1 s.

Experimental setup

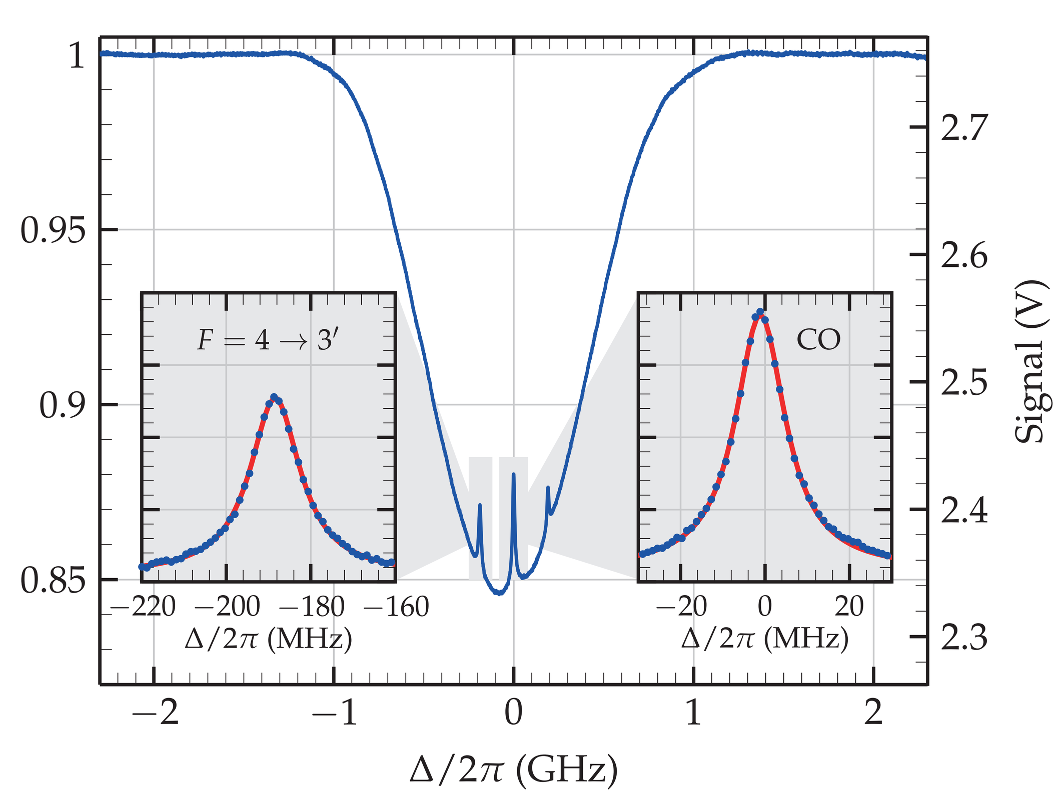


$6S_{1/2}$ - $7P_{1/2}$ transition:
- ν_0 = 6.53 x 10^{14} Hz,
- $\Gamma_N/2\pi$ = 963 kHz

Saturation from the probe



Saturated absorption spectrum



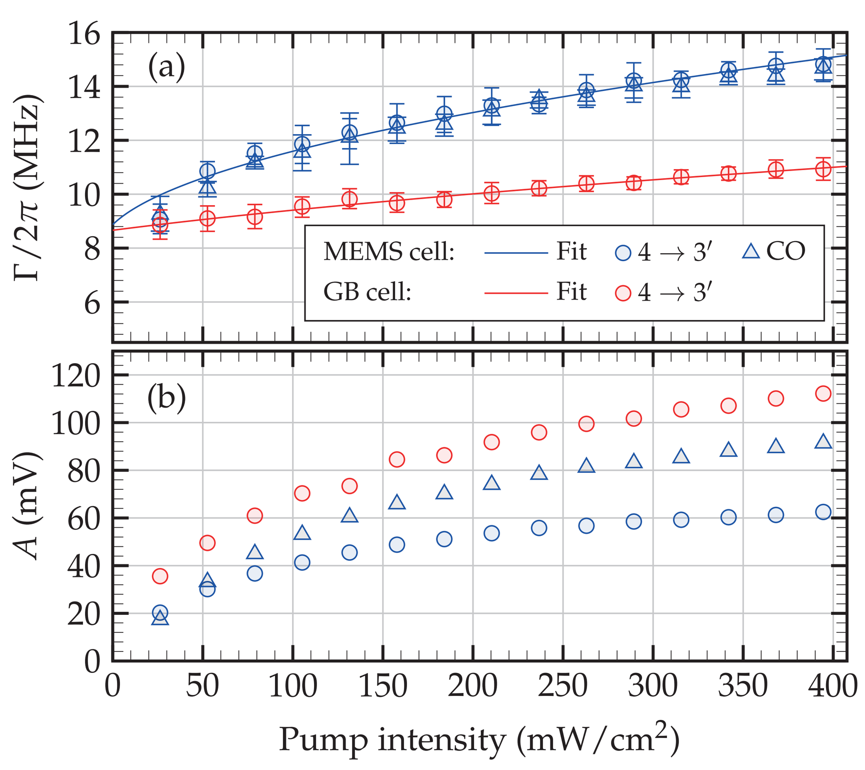
With respect to Cs D_1 line, $6S_{1/2} - 7P_{1/2}$ transition:
- $\Delta\nu$ reduced by ~ 5
- ν_0 increased by ~ 2

} 1 OoM better short-term stability!

Lorentzian fit: $L(\Delta) = \dfrac{A}{1 + (2\Delta/\Gamma)^2}$

Sub-Doppler resonance *vs* exp. parameters

Pump intensity

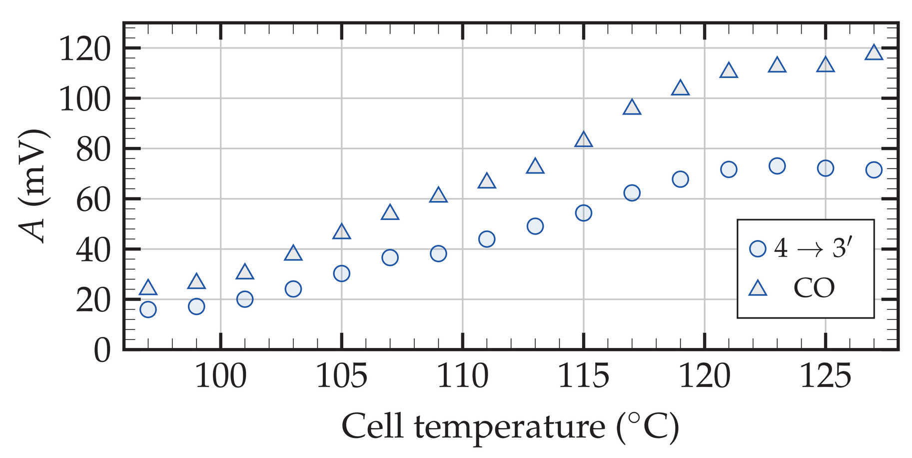


Initial results:
- Optimum for CO: 18 mW (ø2 mm)
- Zero-power linewidth: 7.9(7) MHz

⇒ Presence of impurities

MEMS cell with embeded getter [6]:
- A improved by ~ 2, Γ reduced by ~ 2.5
- Optimum power reduced to ~ 5 mW

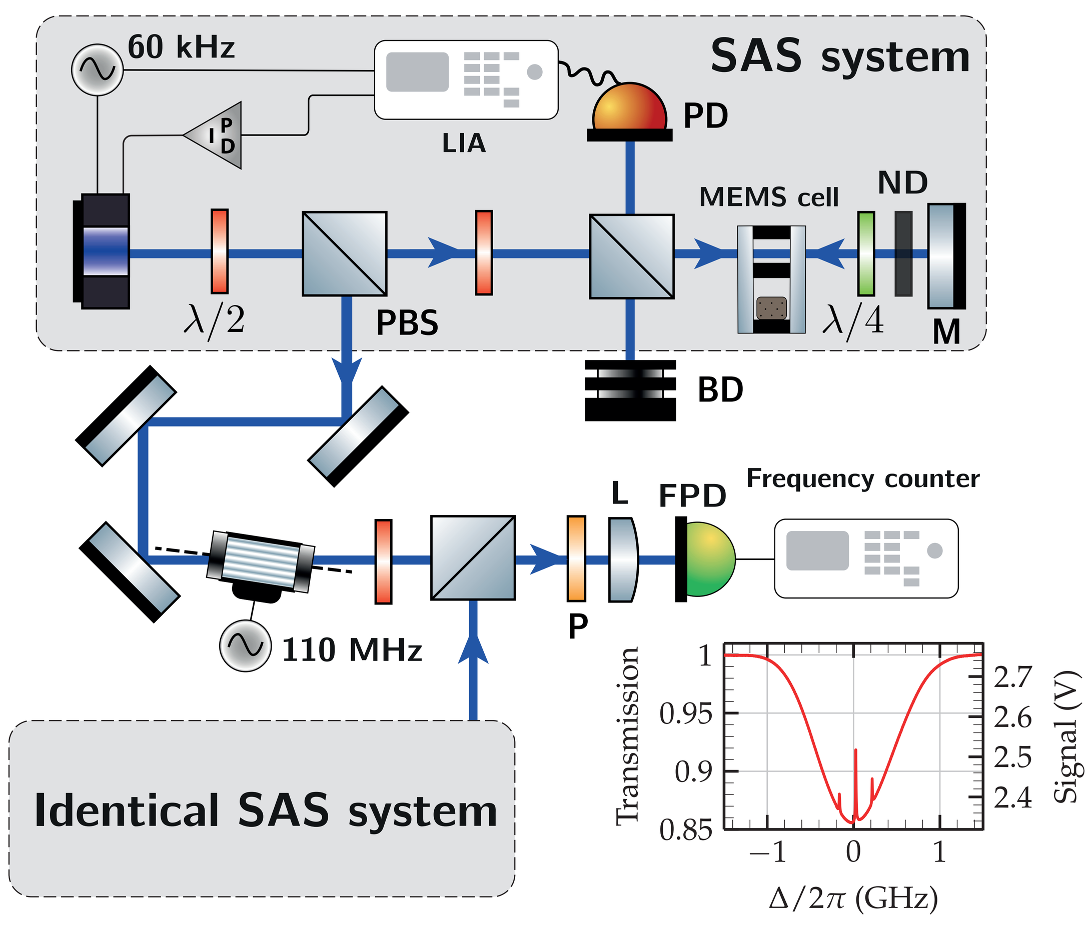
Cell temperature



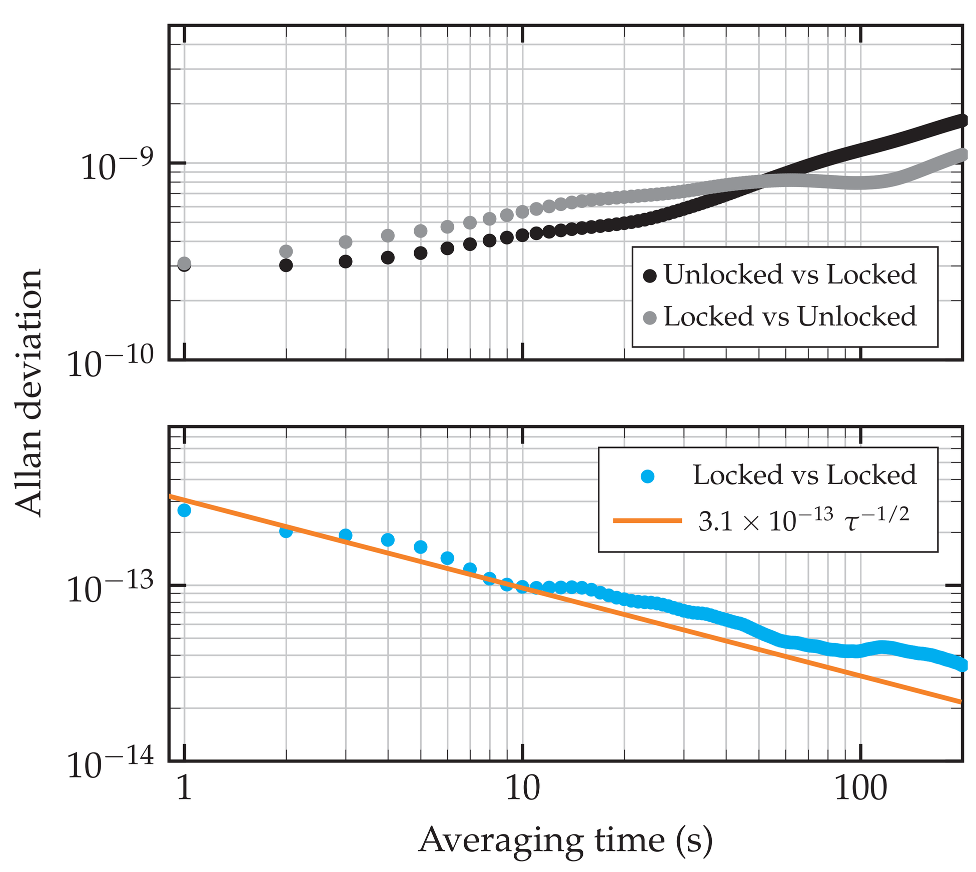
- Optimum: ~ 122°C (no noticable change on Γ)
- No degradation of the MEMS cell observed > 6 months

Beatnote between two identical systems: preliminary results

Beatnote setup



Beatnote Allan deviation



Conclusions & perspectives

Conclusions

- Detection of sub-Doppler resonances at 459 nm in a MEMS cell with SAS
- Identification of optimum parameters for the short-term stability of an optical frequency reference
- Preliminary stability at 1 s in the low 10^{-13} range

Perspectives

- Improve the quality of the locking scheme
- Realize phase noise measurements
- Further improve the cell purity for norrower linewidth
- Explore alternative spectroscopic schemes

References

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