A high-performance CPT-based Cs vapor cell atomic clock using push-pull optical pumping

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To be considered for student competition

Microwave vapor cell atomic clocks are exciting candidates for numerous timekeeping applications because they combine compactness, a modest power consumption and excellent fractional frequency stability at the level of a few $10^{-13}\ \tau^{-1/2}$ [1,2,3]. In the frame of the MClocks project funded by EURAMET, we report on the development of a Cs vapor cell atomic clock based on coherent population trapping (CPT).

The optics part of our clock combines a distributed feedback (DFB) diode laser resonant on the Cs D_1 line at 894 nm, a pigtailed Mach-Zehnder electro-optic modulator driven at 4.596 GHz, an acousto-optic modulator (AOM) and a Michelson-based delay line and polarization orthogonalizer system. The laser is frequency-stabilized on an annex Cs vapor cell using a dual-frequency saturated absorption scheme at the output of the EOM. The optics ensemble allows to produce the so-called push-pull optical pumping (PPOP) scheme [4,5] leading to the detection of high-contrast CPT resonances on the clock transition. CPT interaction occurs in a 2-cm diameter and 5-cm long Cs vapor cell filled with a N_2-Ar buffer gas mixture of total pressure 15 Torr. The typical clock resonance signal exhibits a contrast of about 25% and a linewidth of 400 Hz.

The clock, in continuous regime, has demonstrated a short-term fractional frequency stability at the level of 3 $10^{-13}\ \tau^{-1/2}$ for integration times up to 100 s [6]. These performances, among the best performances ever reported for a CPT-based clock, were recently improved to reach routinely 1.8 - 2 $10^{-13}\ \tau^{-1/2}$ for integration times up to 100 s. The short-term stability is mainly currently limited by laser intensity effects and the Dick effect. The mid-term frequency stability is limited by light-shift effects.

Different aspects will be investigated towards the conference to improve the clock performances: the use of a newly-designed ultra-low phase noise frequency synthesizer to reduce the Dick effect contribution [7] and the implementation of dedicated laser power noise reduction techniques. Additionally, preliminar tests of a Ramsey-like interrogation scheme of the clock transition for reduced sensitivity of the clock frequency to laser intensity variations will be performed. Latest results will be presented at the conference.

References

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