A CPT-based Cs cell atomic clock using auto-balanced Ramsey spectroscopy

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We report the in-progress development of a high-performance compact coherent population trapping (CPT) Cs cell microwave atomic clock. This clock combines the optimized push-pull optical pumping technique [1,2] and a pulsed interrogation method, yielding the detection of high-contrast and narrow Ramsey-CPT fringes. In EFTF2017, the clock fractional frequency stability was reported to be $2.3 \times 10^{-13} \, \tau^{-1/2}$ up to 100 s averaging time, limited on short term by laser AM noise and after 100 s by light-induced frequency shift effects [3].
Over the last months, advanced electronics dedicated to stabilize the laser power in the pulsed regime have been developed. Moreover, the thermal isolation of the clock optical setup has been greatly reinforced. Thanks to these efforts, the clock short-term fractional frequency stability has been improved to the level of $1.4 \times 10^{-13} \, \tau^{-1/2}$ up to 100 s, but still limited on longer time scales by light shift effects.
To tackle this issue, we investigate the application of the auto-balanced Ramsey (ABR) interrogation protocol, recently proposed in [4], to our 3-level system CPT-based atomic clock. The latter interrogation protocol is found to reduce the sensitivity of the clock transition frequency to laser power variations, compared to the usual Ramsey-CPT case.
Combining this method and improvements previously described, the Allan deviation of the clock has been preliminary improved at the level of 6×10^{-15} at 2000 s averaging time, representing an improvement by a factor 33 compared to our best previously reported results [3]. These performances tend to demonstrate that the achievement of low drift CPT-based atomic frequency references using hot vapor cells is possible.
Several tests are under progress to improve further the clock frequency stability performances. This includes the recent implementation on this CPT clock of an ultra-low phase noise microwave frequency synthesizer [5], combined with a high-performance FPGA-based electronics system, for piloting the clock experiment [6]. This also includes the further investigation and characterization of the ABR-CPT protocol. Latest results will be shown at the conference.

References

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