Strontium optical lattice clocks

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Thanks to their large quality factor and the large number of simultaneously interrogated atoms, optical lattice clocks beat frequency stability and accuracy records [1–3].

Here, we propose the demonstration of a set of two operational lattice clocks using strontium atoms. They feature an uncertainty budget below 5×10^{-17}, mainly limited by the black-body radiation shift, and a frequency stability of 1.0×10^{-15}, after a 1 s integration time. The second clock has been operated during a full week, as part of the EMRP-funded project "International Timescales with Optical Clocks" (ITOC), with minimal human intervention. During this period, the clock, linked to a fiber-based frequency comb, provided integration points every second with an uptime larger than 93%. These developments are essential steps towards international comparisons of optical clocks, either by fiber links or via the PHARAO/ACES space clock project.

During this measurement campaign, the Sr clock has been compared to Cs and Rb microwave fountains, providing frequency ratio measurements with a statistical resolution below 10^{-16}, and an improved overall uncertainty over our previous measurement [4]. Moreover, these ratio measurements agree within the error bars with the results publish in [4], reinforcing our confidence in the reproducibility of optical lattice clocks. Furthermore, these results bring improved constraints on a possible drift of fundamental constants.

Finally, we take profit from the reliability of the clock to investigate a pending issue that could have compromised the ultimate performances of OLCs. We propose a study of lattice induced effects by comparing various laser sources for the optical lattice: Semi-conductor tapered amplifiers, slaves lasers and a titanium-sapphire laser. We show that careful characterization of the light is necessary to ensure ultimate accuracy.

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References

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