High-stability Yb optical lattice clock with 10^{-18}-level uncertainty

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In recent years, optical lattice clocks have demonstrated the ability to reach fractional instability at the 10^{-18} level [1,2,3]. Such measurement instability plays a vital role in the detailed characterization of systematic effects influencing the lattice clock. We report on a systematic evaluation of the NIST Yb optical lattice clock with a total uncertainty at the 10^{-18} level, and detail the experimental measurements which support this uncertainty. Utilizing an enhancement cavity, we have quantified lattice Stark shifts over a wide range of trap depths, yielding a precise measure of both hyperpolarizability and scalar polarizability effects. The cold atom sample is enclosed in a room-temperature blackbody shield, thereby enabling determination of the BBR Stark shift with an environmental uncertainty of 5×10^{-19}[4]. This enclosure also functions as a Faraday shield against stray electric fields. With the ability to apply high voltage potentials directly to the shield windows, we have experimentally confirmed that stray DC Stark shifts are consistent with zero at a level of $\leq 4 \times 10^{-19}$. Weak transversal confinement in the optical lattice and ultracold atomic temperatures (2-3 μK) which suppress p-wave atomic interactions [5] limit density-dependent shifts to the 10^{-18} level. Residual first-order Doppler effects due to lattice phase variations are measured and then nulled with active compensation. Furthermore, we have performed improved measurements of the probe AC Stark shift and second-order Zeeman shift. Comparative measurements between two Yb optical lattice clocks will also be reported at the 10^{-18} level. Finally, the implementation of an improved optical local oscillator for the clock transition at 578 nm will be described, towards achieving a clock frequency instability of $\leq 1 \times 10^{-16} / \tau^{1/2}$, for averaging time *t*.

References

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