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Zero-dead-time Differential Spectroscopy Beyond the Laser Coherence Limit

Thursday, 8 July 2021 19:00 (30 minutes)

To avoid ambiguity in the phase readout, optical clock measurements are constrained to operate with an interrogation time that is short enough that the accumulated optical local oscillator (OLO) phase wander remains within $\pm\pi/2$ radians. This constraint, known as the coherence limit, has motivated a variety of techniques to allow interrogations beyond this limit. A recent proposal has been put forward to take advantage of the different clock frequencies of two distinct optical clocks, affording interrogation which extends beyond the coherence limit [1].

In this scheme, the two clock interrogations are synchronized with each other, and their OLOs are locked together by means of an optical frequency comb. By quickly feeding forward the results of phase measurements from one clock (an Yb optical lattice clock), the interrogation time of the other (an Al^+ single-ion clock) can be extended by a factor of the frequency ratio of the clocks. By sending phase corrections from both Yb clocks in a zero-dead-time configuration, interrogation can be extended much further, with only technical limitations remaining. With this configuration, we realize quantum-projection-noise-limited clock instability for interrogation times of several seconds.

We have demonstrated a novel and highly versatile interrogation protocol which has allowed the achievement of a record inter-clock instability representing a nearly order-of-magnitude improvement over our previous measurement. This level of performance can facilitate the achievement of 10^{-19} decade ion clock instabilities in the course of a single day of measurement and is extendable to a wide variety of inter-clock comparisons, including systems with high sensitivities to variation in the fundamental constants, such as the Yb^+ E3 clock.

[1] Hume, D. B., & Leibrandt, D. R. (2016). Probing beyond the laser coherence time in optical clock comparisons. Physical Review A, 93, 032138. https://doi.org/10.1103/PhysRevA.93.032138

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