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Comparisons of Optical Frequency Standards at NIM

Tao Yang(1)(2), Qiang Wang(1)(2), Haochen Tian(1)(2), Bingkun Lu(1)(2), Fei Meng(1)(2), Tangyin Liao(1)(2)(3), Hao Liu(1)(2)(4), Ye Li(1)(2), Baike Lin(1)(2), Lin Zhu(1)(2)(3), Zhanjun Fang(1)(2) and Yige Lin*(1)(2)
(1) Division of Time and Frequency Metrology, National Institute of Metrology, Beijing 100029, People's Republic of China, email:linyige@nim.ac.cn
(2) Key Laboratory of Time Frequency and Gravity Primary Standard, State Administration for Market Regulation, Beijing 100029, China
(3) Department of Precision Instrument, Tsinghua University, Beijing 100084, People's Republic of China
(4) Institute of Precision Optical Engineering, School of Physics Science and Engineering, Tongji University, Shanghai 200092, China

According to the roadmap toward the redefinition of the second released by the Consultative Committee for Time and Frequency (CCTF) of the International Bureau of Weights and Measures (International Committee for Weights and Measures CIPM), verifying the accuracy budgets of the optical frequency standards (OFSs) has become the top priority task at present.

Two ^{87}Sr optical lattice clocks (OLCs) are being developed at the National Institute of Metrology of China (NIM). In 2021, the systematic shift uncertainty of NIM-Sr1 was evaluated to be 2.9×10^{-17} on NIM's Hepingli Campus[1, 2]. Similarly, NIM-Sr2 achieved a systematic shift uncertainty of 6.5×10^{-18} in 2023 on NIM's Champing Campus[3, 4].

In order to compare the optical frequencies of these two Sr OLCs, a 58-km noise canceled fiber link is established to transfer both a 1542-nm transfer laser and a microwave reference from Changping campus to Hepingli campus. Two commercial optical frequency combs (OFCs) with adapted single-branch 698/1542 nm outputs coherently unite the two 698-nm clock lasers and the 1542-nm transfer laser. The fractional instability of the comparison yields 3.1×10^{-17} at 10000 s averaging time. The measured fractional frequency difference between these two Sr OLCs evaluated to be $1.9(3.2) \times 10^{-17}$ is within their claimed uncertainties, which shows the consistency of the frequencies of these two Sr OLCs when serving as OFSs[5].

A transportable Ca^+ optical clock is operated at NIM's Chanping campus. This clock was developed by the Innovation Academy for Precision Measurement Science and Technology (APM). In order to reduce the statistical noise of the frequency comparison between the Ca^+ and Sr optical clocks, the local oscillator of the Ca^+ clock is frequency-synthesized from the Sr OLC, which improves the frequency stability of the Ca^+ clock. The frequency ratio measurement instability between the two optical clocks reaches $2.2 \times 10^{15}/\sqrt{\tau}$[6].

References

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