Hydrogen Maser Flywheels for Optical Clocks

N. Nemitz, **H. Hachisu, H. Ito, N. Ohtsubo, Y. Miyauchi, M. Morikawa, K. Matsubara, T. Ido**
Space-Time Standards Laboratory, NICT, Koganei, Tokyo, Japan
email: nils.nemitz@nict.go.jp

Until long-term frequency stable optical references [1] reach the robustness needed to operate as signal sources free from interruptions, hydrogen masers (HM) remain the best available option for a flywheel oscillator that can bridge both accidental and intentional gaps in the operation of an optical frequency standard. NICT's approach of operating its strontium optical lattice clock NICT-Sr1 only intermittently [2] is designed around the stability of the hydrogen masers operated for the generation of Japan Standard Time (JST) [3].

From October 29, 2021 to March 30, 2023, NICT-Sr1 performed 78 frequency evaluations of hydrogen maser JST-HM14, typically to a statistical fractional uncertainty of $2–3\times10^{-16}$. Isolating each evaluation from the full dataset and comparing it to an interpolation of the remainder yields prediction errors with a standard deviation of only 5.0×10^{-16} (Fig. 1), in good agreement with the statistical uncertainty of 5.6×10^{-16} calculated using our previously reported stochastic HM model [4]. The same model yields an uncertainty of 1×10^{-15} or below when extrapolating the HM behavior to the next weekly clock measurement. These uncertainties support that intermittent operation of a precise optical clock, combined with a well-performing hydrogen maser acting as a predictable flywheel oscillator, is sufficient to generate a time scale with excursions at or less than 1 ns over several weeks.

Our poster will show greater detail on this and similar evaluations spanning optical and radio-frequency domains.

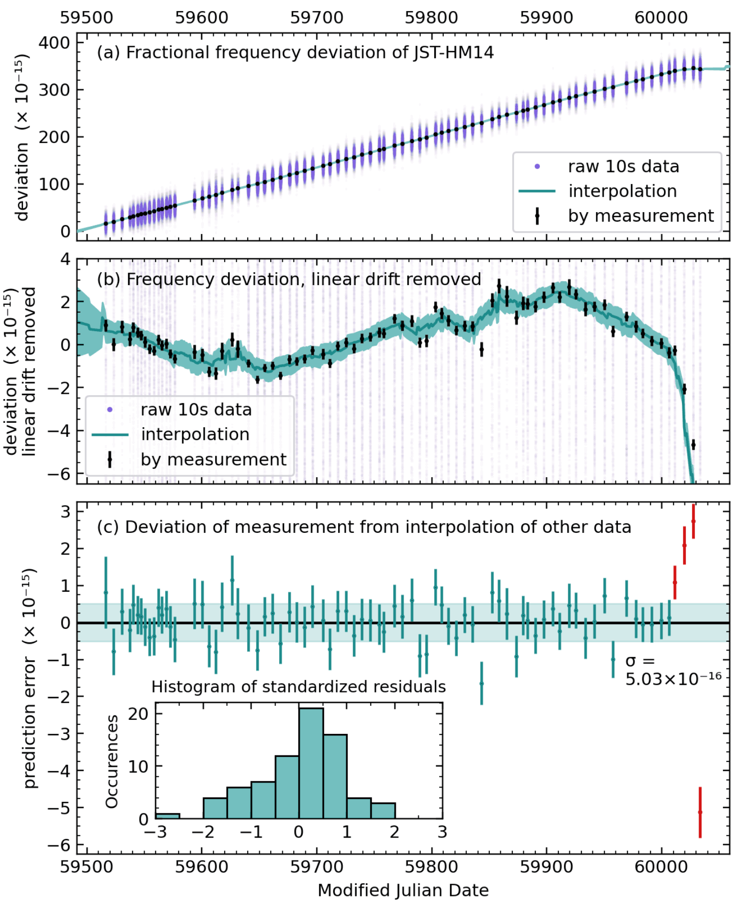

Fig.1.(a, b): Frequency tracking of hydrogen maser JST-HM14 by NICT-Sr1 over more than 500 days. (c) Each measurement is compared to an interpolation of the data taken in other measurements. JST-HM14 depleted its hydrogen reservoir at the end of the measurement, and the last four points were excluded from the statistical evaluation.

References

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