Realization of a Rubidium Atomic Frequency Standard with short-term stability in $10^{-14}\tau^{-1/2}$ level

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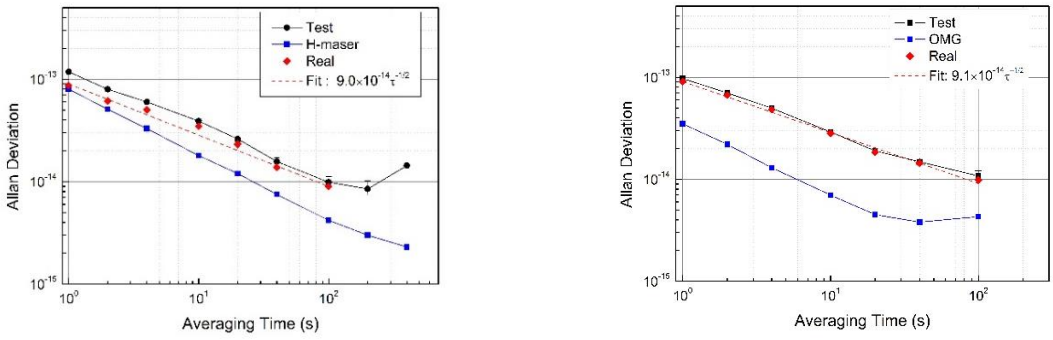
Lamp-pumped rubidium atomic frequency standard (RAFS) is one of the most widely utilized atomic frequency standards. Over the past few decades, the RAFS's frequency stability performance has improved rapidly, and the best one has been in the $10^{-13}\tau^{-1/2}$ level[1]. In this presentation, we report an RAFS with stability in the $10^{-14}\tau^{-1/2}$ level for the first time. In design of the physics package (PP), a rubidium spectral lamp with Xe as the starter gas was used as the pumping light source. The light was filtered by using optical and isotope double-filtering technique. A large slotted tube microwave cavity and a rubidium absorption cell with a diameter of 40 mm were utilized to enhance the atomic discrimination signal[2]. A sealed box was designed for the PP to isolate it from the barometric environment. A low phase noise 6.835-GHz microwave was employed to interrogate the rubidium clock transition. Based on the quantitative analysis of the signal-to-noise ratio (SNR) of the atomic discrimination signal and the phase noise of the interrogation microwave, the stability of the RAFS was predicted to be $7.6 \times 10^{-14}\tau^{-1/2}$. The short-term stability of the RAFS was measured by using a hydrogen maser and an optical microwave generator (OMG) as references, and the results are $9.0 \times 10^{-14}\tau^{-1/2}$ (1–100 s) and $9.1 \times 10^{-14}\tau^{-1/2}$ (1–100 s), respectively. The measured results are in agreement with the predicted one. More experimental detail will be discussed in the presentation[3].



(a) (b)

Fig.1 Two references were employed for the frequency stability test of the RAFS. One is a high-performance active hydrogen maser (H-maser) produced by KVARZ (CH1-95), and the other, an ultra-stable laser based optical microwave generator (OMG). Frequency stability test results of the RAFS. And (a) is the frequency stability result using the H-maser as the reference and (b) being the OMG as the reference.

[1] G. Mei, et al., "Main features of space rubidium atomic frequency standard for BeiDou satellites", 2016 EFTF, York, UK, pp. 1-4, 2016.
[2] J. Cui, et al., "Design and studies of an ultra high-performance physics package for vapor-cell rubidium atomic clock", 2022 CSNC, Beijing, China, pp. 403-414, 2022.
[3] J. Cui, et al., "Realization of a rubidium atomic frequency standard with short-term stability in $10^{-14}\tau^{-1/2}$ Level", IEEE Transactions on Instrumentation and Measurement, vol. 73, pp. 1-7, 2024.