UTC(k) steered by intermittent operation of an optical clock

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UTC (Coordinated Universal Time) is a so-called paper clock timescale derived from the weighted average of more than 400 clocks worldwide, providing an extremely robust foundation to the time infrastructure of modern society. Thus, most countries base their national time on UTC, typically with a time zone correction of an integer or half-integer number of hours. National standard time is a real signal and needs to be disseminated without interruptions, but since UTC is determined with a latency of one month, each time and frequency laboratory "*k*" operates its own clocks to generate a real-time signal UTC(*k*) maintained as close as possible to UTC. Traditionally, standard time has been generated using microwave frequency standards such as cesium atomic clocks or hydrogen masers, but to take advantage of the improved performance of optical clocks and in preparation for the future redefinition of the second, it is desirable to determine the scale interval of standard time by such an optical clock. However, continuous operation of optical clocks is not yet easy and redundancy of clocks is difficult to attain since commercial optical clocks are not yet available.

NICT has been studying methods to generate real time signals with a scale interval based on an optical clock. In 2016 a timescale TA(Sr) was first generated [1], using a single hydrogen maser (HM) with an output signal that was steered by reference to an ^{87}Sr optical lattice clock. Further increased stability can be achieved by considering a larger HM ensemble [2]. But with no redundancy in the source oscillator or the Sr system, it is difficult to use such a system as a source of UTC(*k*). In contrast, the Japan Standard Time (JST) system generates a numerically calculated ensemble timescale from more than 15 Cs atomic clocks, and obtain three real time signals (for redudancy) by steering three HMs independently to this product with a certain offset frequency f_{offset}.

A method for incorporating an optical clock is then to adjust f_{offset} to compensate for the difference between UTC(NICT) and TA(Sr). If any problem affects the generation of TA(Sr), effects on UTC(NICT) can be avoided by suspending the steering to TA(Sr) and reverting the steering to the ensemble of radio frequency clocks. NICT has been generating UTC(NICT) and JST in this way since August 2021. Since then, |UTC−UTC(NICT)| has been reduced from 20 ns to 5 ns as shown in Fig. 1(a). As shown in Fig. 1(b), however, the stability of UTC(NICT) over the period between measurements remains limited by the performance of the Cs ensemble. For this reason, we are investigating adding hydrogen masers to the clock ensemble and modifying the algorithm to incorporate clocks with predictable frequency drifts [3]. We will also present preliminary results of this improved scheme.

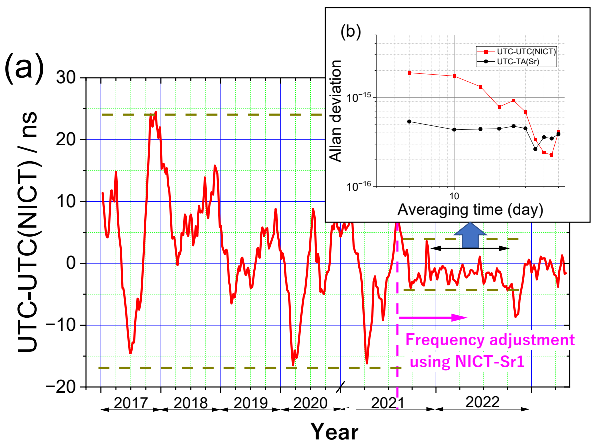

Fig.1 (a) Record of UTC−UTC(NICT) (b)Allan deviation of UTC(NICT) and TA(Sr) obtained in the operation of ten months (black arrow)

References

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[3] G. Panfilo, A. Harmegnies and L. Tisserand, "A new prediction algorithm for the generation of International Atomic Time", Metrologia 49, 49, 2012.