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Time and frequency dissemination over 113 km free-space

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Networks of optical clocks find applications in precise navigation, in efforts to redefine the fundamental unit of the 'second'and in gravitational tests. As the frequency uncertainty and instability for state-of-the-art optical clocks has reached the 10ˆ−19 level, the vision of a global-scale optical network that achieves comparable performances requires the dissemination of time and frequency over a long-distance free-space link with a similar instability of 10ˆ−19.

Here, we report time–frequency dissemination with an offset of 6.3 × 10−20 ± 3.4 × 10−19 and an in-stability of less than 4 × 10−19 at 10,000 s through a free-space link of 113 km [1]. Key technologies essential to this achievement include the deployment of high-power frequency combs, high-stability and high-efficiency optical transceiver systems and efficient linear optical sampling. We observe that the stability we have reached is retained for channel losses up to 89 dB.

The experiment was performed in Urumqi, Xinjiang Province. Two terminals (A and B) are located at Nanshan and Gaoyazi with a distance of 113 km. Each terminal is equipped with an ultra-stable laser (USL), two 1-W optical frequency combs with different wavelengths centered at 1,545 nm and 1,563 nm, two LOS modules and an optical transceiver telescope. The OFC optical phase locked to the USL is used as the carrier and reference signals of the local sampling [2]. By frequency multi-plexing the common free-space channel, we establish two independent two-way time–frequency transfer links, enabling precise evaluation of the link performance without limitation from the USL. As the two multiplexing channels share the same free-space link, common-mode noise occurs. To better evaluate our system, we also established an independent fibre link connecting the two termi-nals with a distance of 209 km. All links share the same USL at each terminal. Experimental results are shown in Fig. 1.

The work successfully evaluates the possibility of a satellite-based time–frequency dissemination on loss and noise. Next step, we will try to overcome other difficulties such as Doppler effects, link back-forward asymmetry and so on. Hopefully, we can have global optical clock networks in near future.

References

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