Harmonizing Timekeepers over Long-Distance with Ultra-Precision

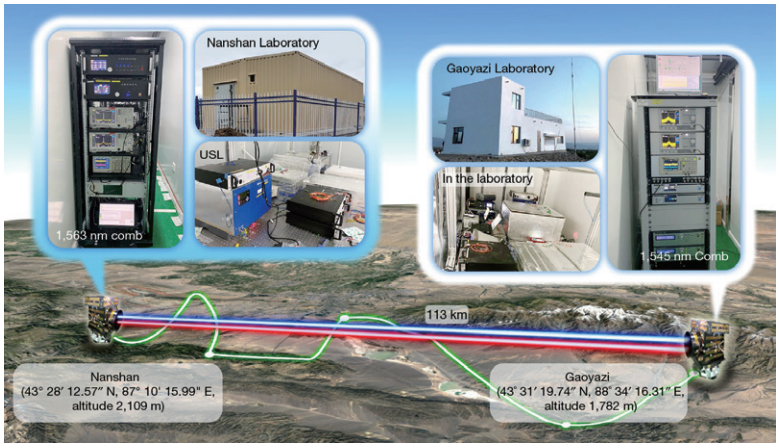
By YAN Fusheng (Staff Reporter)

On October 5, 2022, a research team led by Prof. PAN Jianwei and his colleagues from the University of Science and Technology of China (USTC) reported free-space dissemination of time and frequency with 10^{-19} instability over 113 kilometers, paving the way for the future development of global-scale optical clock networks and precision timekeeping.

The study entitled "*Free-space dissemination of time and frequency with 10^{-19} instability over 113 km*" was published in the high-impacting journal of *Nature*.

When you imagine timekeeping as a vast global orchestra, each instrument can then be seen as a different clock. To play a harmonious symphony, all the instruments need to be perfectly in tune and synchronized with each other. In the world of precision timekeeping, optical clocks are like the finest instruments, capable of playing incredibly precise and accurate notes.

In this study, researchers have discovered a way to make sure these "instruments" can play in perfect harmony over long distances by transmitting their "notes" (time and frequency information) through the "air" (free-space links) without losing precision and accuracy. This is like enabling a violinist in New York and a pianist in Philadelphia to play a duet in perfect synchronization, even though they are 113 kilometers (about 70 miles) apart.



The experimental setup leads to free-space time–frequency dissemination with 10^{-19} instability over 113 kilometers. (Image by USTC)

This breakthrough in timekeeping "music" can benefit many areas of our lives, from helping us navigate the world with pinpoint accuracy to conducting sophisticated scientific experiments that rely on extremely precise timing.

In the future, this technology could even enable "musicians" (optical clocks) on Earth and in space at the same time to play in perfect harmony, opening new possibilities for scientific discovery and technological innovation.

Reference

Shen, Q., Guan, J. Y., Ren, J. G., Zeng, T., Hou, L., Li, M., . . . Pan, J. W. (2022). Free-space dissemination of time and frequency with 10^{-19} instability over 113 km. *Nature, 610*(7933), 661–666. doi:10.1038/s41586-022-05228-5