Free-space-based quantum two-way time transfer

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By virtue of the strong temporal correlation characteristics of energy-time entangled photon pair sources, the quantum-enhanced two-way time transfer (Q-TWTT) was proposed and its superiority has been proved convincingly over fiber links. The implementation of Q-TWTT on free-space links becomes an urgent need for remote time transfer expanding to the transcontinental distance. In this presentation, the Q-TWTT experimental demonstration over a hybrid link of turbulent free-space and field fiber is reported[1]. An overview of the Q-TWTT setup is illustrated in Fig. 1(a). The line-of-sight distance between the master station (MS, the campus of National Time Service Center, Chinese Academy of Sciences, China) and the remote station (RS) on a mountain is about 2 km. In addition, a 7 km-long field fiber was also deployed between the two sites. Despite the significant loss of ~30 dB and atmospheric turbulence, three overnight measurements were carried out under slightly different system settings. With the optimized configuration, the time transfer stability showed a time deviation (TDEV) of 1.71 ps at an averaging time of 50 s and 144 fs at 6400 s in Fig. 1(b). This achievement shows the good feasibility of quantum-enhanced time transfer in the space-ground integrated optical links and nicely certifies the capability of Q-TWTT in comparing and synchronizing the state-of-the-art space microwave atomic clocks[2].

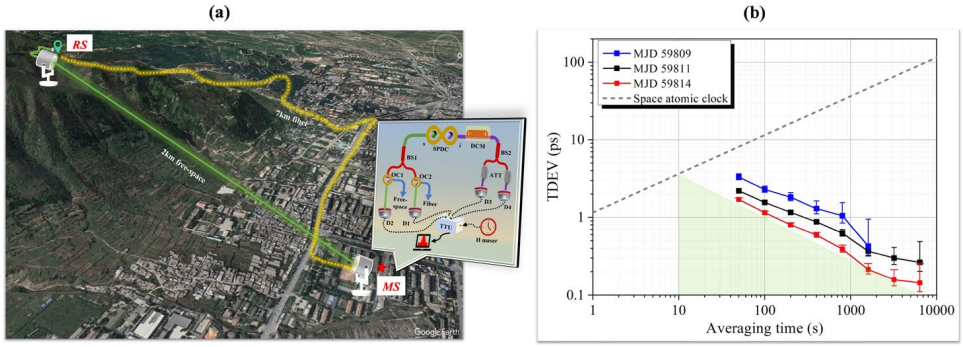

Fig. 1 (a) Schematic diagram of the Q-TWTT over a hybrid optical link; (b) Measured TDEVs of recovered time offsets from three overnight runs.

[1] X. Xiang et al, "Quantum two-way time transfer over a hybrid free-space and fiber link", Quantum Sci. Technol., vol. 8, 045017, 2023.

[2] B. L. S. Marlow and D. R. Scherer, "A review of commercial and emerging atomic frequency standards", IEEE Trans. Ultrason. Ferroelectr. Freq. Control vol. 68 p. 2007-2022, 2021.