Developing a Free-Space Quantum-Secure Time Transfer System

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Clock synchronisation is vital in maintaining accurate location and time data of Global Positioning System (GPS) satellites. It is also desirable that the time transfer is secure from attacks. Unfortunately, transmission of GPS radio frequency signals can be easily jammed via the introduction of noise such that the signals are no longer detected by receivers. Furthermore, GPS signals can be spoofed whereby false time and location information is sent to a receiver. Quantum clock synchronisation protocols have been proposed as an alternative to GPS that would provide unspoofable and precise time transfer [1]. The most well-known experiment to date involved the transmission of an optical quantum time-transfer signal between the Micius quantum satellite and a ground station in China in 2020 [2].

Here we will present our latest results investigating the effects of perturbations such as loss and noise to a free-space quantum time transfer link. Using the setup illustrated in Figure 1(a) with the corresponding correlation peak in Figure 1(b), we have demonstrated free-space time transfer with picosecond resolution. With an integration time of 0.5 seconds, our results show that correlations can still be detected when the noise level is 200 times higher than the signal level. The maximum amount of loss accepted by our system is 38 dB. We also compare our experimental results to a theoretical model to determine the fundamental limits of free-space optical quantum time transfer.

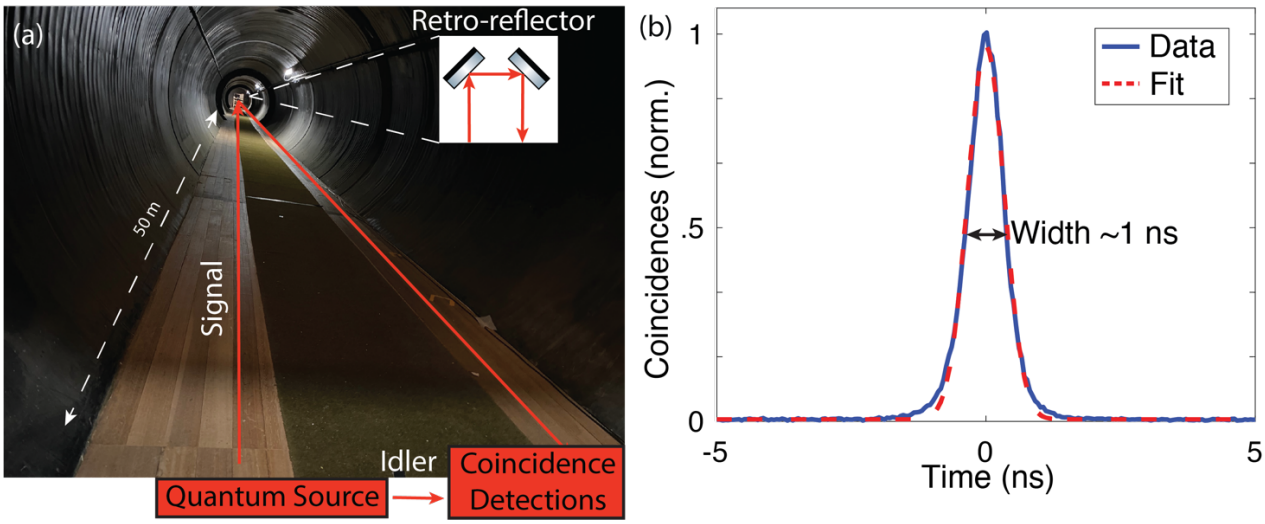

Figure 1(a) Correlated photon source system. (b) Correlation peak. Full-width-at-half-maximum of the correlation histogram represents the precision of clock synchronisation.

[1] A. Valencia, G. Scarcelli, Y. Shih *Appl. Phys. Lett.* **85**, 2655 (2004).

[2] H. Dai, Q. Shen, C.-Z. Wang *et al. Nat. Phys.* **16**, 8 (2020).