

• Supplementary File •

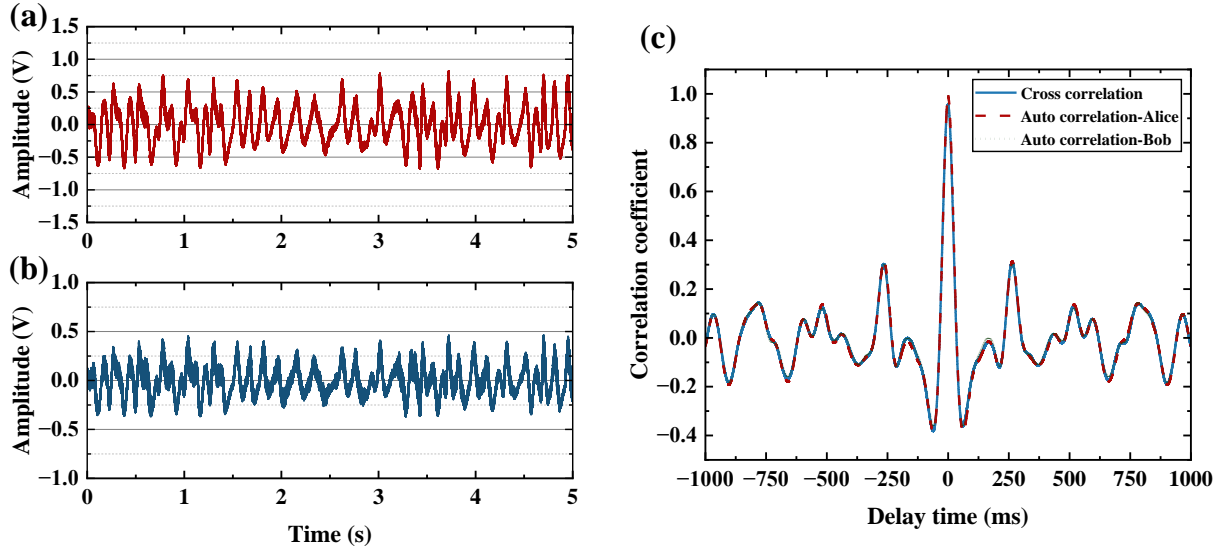
# Integrated optical frequency transfer and optical physical layer key distribution with enhanced link reciprocity detection

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## Appendix A The waveforms recorded by Alice and Bob

Figure A1 (a), (b) show the random intensity waveforms obtained by Alice (upper, red) and Bob (lower, blue) over a reciprocal link, which are recorded by real-time scope with a sampling frequency of 125 ks/s. We can clearly see that the fluctuation patterns between the two random waveforms are very similar, which indicates that the two random waveforms recorded by Alice and Bob are highly correlated with each other. For OKD, a highly correlated random entropy source facilitates better key generation and distribution performance. To evaluate quantitatively the similarity between the measured waveforms by different users, after time synchronization, linear correlation coefficient is calculated using the cross-correlation algorithm. Figure A1 (c) shows the cross-correlation function between the two random waveforms. The results show that the cross-correlation coefficient peak is better than 0.98, validating the feasibility of the OKD based on the proposed integrated OFT and OKD scheme.



**Figure A1** (Color inline) Measured random waveforms by (a) Alice (upper, red) and (b) Bob (lower, blue) over the reciprocal link; (c) Cross-correlation and auto-correlation functions of the signals obtained over the reciprocal link.

Figure A2 (a), (b) show the random waveforms obtained by Alice (upper, red) and Bob (lower, blue) over a non-reciprocal link. There is no obvious correlation between the patterns of change in the two waveforms. And the correlation coefficient with any time delay is less than 0.1, as shown in Figure A2 (c), which indicate that the random waveforms recorded by Alice and Bob are completely uncorrelated with each other. The recorded random waveforms are employed as the entropy source for key generation under actual operating conditions, over the non-reciprocal link, the BER of the secure communication based on OKD will be significantly increased.

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