

Tomography of distributed single-photon entangled state

Ewan MER^{1,2}, Yazeed K. ALWEHAIBI^{1,2}, Shang YU^{1,2}, Ian A. WALMSLEY^{1,2,3}, Raj B. PATEL^{1,2}

¹ *Blackett Laboratory, Department of Physics, Imperial College London,
Prince Consort Rd, London, SW7 2AZ, United Kingdom*

² *Centre for Quantum Engineering, Science and Technology (QuEST),
Imperial College London, Prince Consort Rd, London, SW7 2AZ, United Kingdom*

³ *University of Oxford, Department of Physics, Parks Road, OX1 3PU Oxford, United Kingdom*

Distributing entanglement is pivotal to share quantum information over long distances by entanglement swapping protocols, for various applications such that in communication, metrology, and computing. Entanglement swapping protocols consist of performing a Bell-state measurement at a central station to share entanglement between two separate parties. Full-optical entanglement swapping protocols require limited overhead compared to quantum-memory protocols. So far, most of implemented full-optical entanglement swapping protocols are built upon sharing polarization-entangled states and measuring two photons after a balanced BSM, which results in linear scaling of the success rate with respect to the distance to the central station. Single-photon entangled state is a promising alternative to polarization-entangled state by exhibiting a square-root scaling of the success rate. We report the heralding of the single-photon entanglement state and performing a tomographic reconstruction of the state by using two weak-field homodyne measurement with click detectors. We report a positive concurrence of $C = (8 \pm 6) \times 10^{-3}$ after state reconstruction and a postselected concurrence of $C_{\text{pos}} = 0.462 \pm 0.005$, which signals entanglement between the two parties. We also report a measurement of the Q-function of the signal-photon entangled.

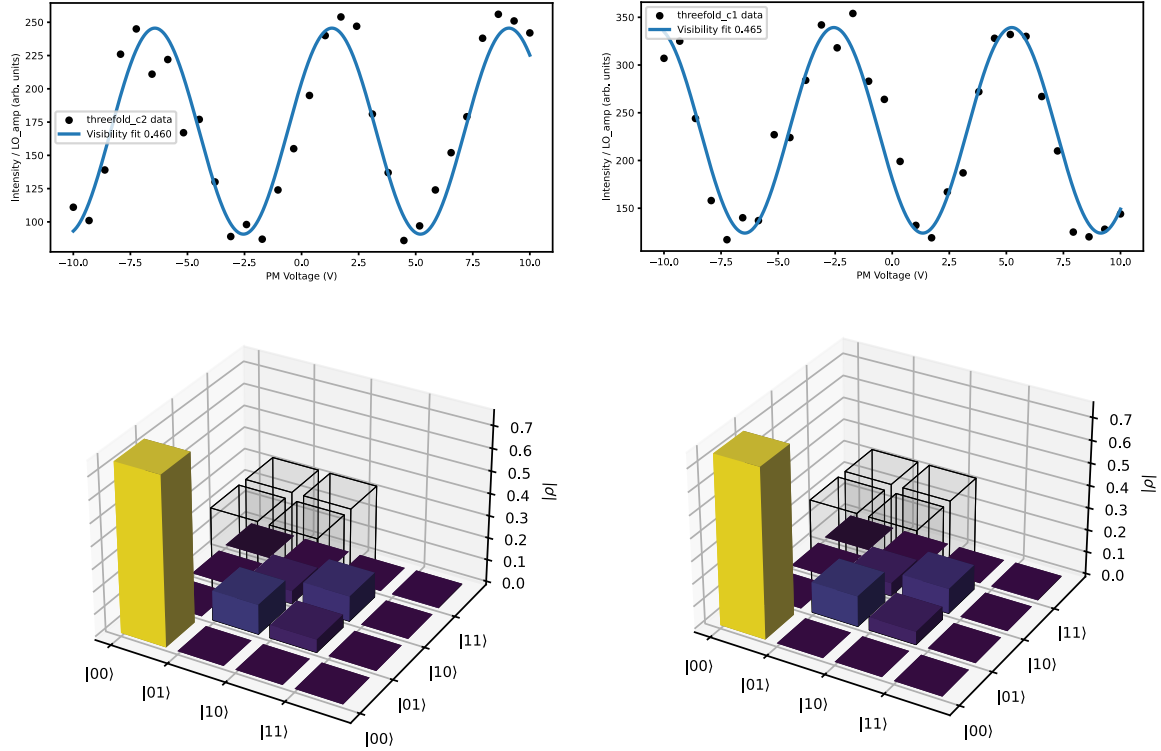


Fig. 1. Top row Two-fold coincidences between Alice and Bob heralded on a click detection at C1 (left) or C2 (right) after a phase sweep of the local oscillator phase. The fitted visibility of the oscillation is 46.5% on the left panel and 46.0% for the right panel. Bottom row Density matrix reconstruction of the shared state between Alice and Bob. The concurrence from the reconstructed density matrix are $(7 \pm 5) \times 10^{-3}$ and $(8 \pm 6) \times 10^{-3}$ for the left and right panel respectively, 0.462 ± 0.005 and 0.458 ± 0.006 for the concurrences after postselection respectively.

Funding acknowledgement

This work was funded by UK Research and Innovation Future Leaders Fellowship (project MR/W011794/1) and the National Company of Telecommunications and Information Security (NTIS) and partly funded by National Research Council of Canada (project QSP 062-2), EU Horizon 2020 Marie Skłodowska-Curie Innovation Training Network (project no. 956071, 'AppQInfo'), UK Research and Innovation Guarantee Postdoctoral Fellowship (project EP/Y029631/1).