Controlling the generation of large cluster states with residual visibility measurements

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Entanglement is a key resource to scale up photonic quantum technologies pertaining to quantum computing or quantum communications [1].
We present a resource-efficient way to generate large states of entangled photons, known as photonic linear cluster (LC) states. We use a bright single photon source, here an InGaAs quantum dot embedded within a micropillar cavity [2], and a fibered entangler (See Fig. 1a) [3], composed of a polarizing beamsplitter and a fibre delay loop.
To increase the number of photons in the LC state, we develop a practical optimization of the experimental setup, based on residual visibility measurements. By changing the phase in the delay loop, we extract a visibility measurement that is directly related to the quality of the generated state. We usually post-select on measuring the same number of input and output photons. The residual visibility method consists in looking at the visibility measurements of 2 to n-1 photons entangled together, in a n-photon experiment – measurement that require much smaller acquisition time. Optimizing the residual visibilities attests the high level of alignment of the experiment and allows to extract information on the system comprised of the source and the loop. Using this method, we demonstrate entanglement of up to 6 photons in a linear cluster state.

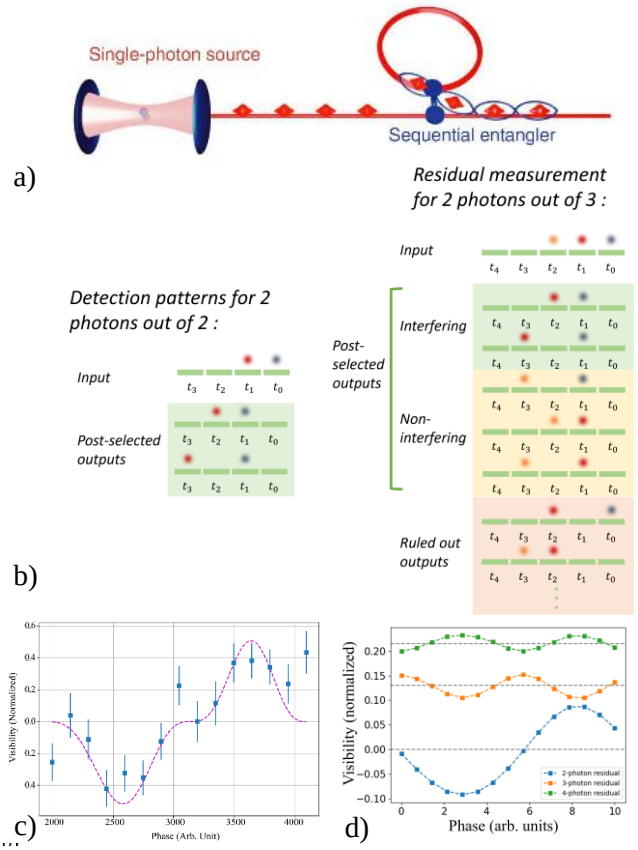

Figure 1: a) Principle of our resource efficient linear cluster state generation protocol [3]
b) Principle of residual visibility measurement – We look at patterns in the temporal modes, removing 1 or more photons leads to a global addition of interfering and non-interfering events to the measurement –
c) 6-photon entanglement measurement - A visibility higher than 0.3 ensures genuine 6-photon entanglement - Experimental value of 0.5±0.1 in agreement with the theoretical model considering 86% Hong-Ou-Mandel
d) Residual visibility measurement of 2, 3, 4 photons out of the 6-photon experiment.

References

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