Programmable multi-photon quantum interference in a single spatial mode.

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The interference of non-classical states of light is crucial for a wide range of quantum-enhanced applications. However, the practical implementation of complex quantum protocols on photonic platforms requires a growing number of physical resources, ranging from more photon sources to larger networks and multiple detectors. Here, we demonstrate a highly efficient quantum photonic processor based on a quantum dot single-photon source, a programmable time-bin interferometer, and only one detector (Fig. 2). The time-bin interferometer is based on active and tuneable linear optical elements, and a fibre loop (Fig.1), as proposed in [1]. With our device we observe the interference of up to 8 photons in 16 modes. To provide evidence of quantum interference in our processor, we employed two *Boson Sampling* validation techniques [3,4] against alternative hypothesis for our experimental statistics.
Our results can form the basis for a future resource-efficient universal photonics quantum processor.

References

[1] K. R. Motes et al., Phys. Rev. Lett. **113**, 120501 (2014).
[2] I. Agresti et al., Phys. Rev. X **9**, 01101 (2019).
[3] S. Aaronson et al., arXiv: 1309.7460 (2013).

Figures

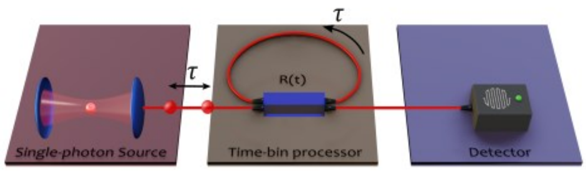

Figure 1: Architecture. A single-photon source is triggered at time intervals τ to prepare a train of n single-photons in m designed time bins along a single spatial trajectory. The photons stream is then propagated through a time-bin processor, the core of which consists of a beamsplitter with time-varying programmable reflectivity. One output of the beamsplitter is connected by a fiber loop to one of the inputs and traverses a delay matched to the arrival of a subsequent input photon at time τ. In this way, the device implements an arbitrary beamsplitter action between consecutive time-bins.

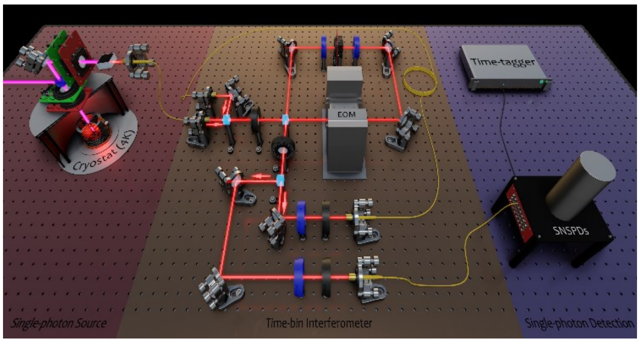

Figure 2: Experimental setup (cfr. Fig.1). The source is an InGaAs quantum dot coupled to a micro-pillar cavity. The tuneable beamsplitter is implemented as a free-space Sagnac interferometer, whose optical paths pass through the electro-optical phase modulator (EOM). The EOM controls the time-varying reflectivity, which can be reconfigured to any value for each time bin. After traversing the fiber loop a number of times, all photons and time-bins exit the processor and are detected with only one detector (SNSPD). The resulting statistics is reconstructed by post-processing events registered by the time-tagger.