Quantifying *n*-photon indistinguishability on-chip

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Quantum states made of many indistinguishable photons are key resources in optical quantum technologies [1]. However, experimentally quantifying the multi-photon indistinguishability of a state of many photons is non trivial [2]. We propose a novel way to accomplish this task using an interferometer that has N = 2n modes and includes a cyclic array of beam splitters, which gives rise to quantum interference when n photons are injected. We experimentally demonstrate this technique using 4 photons from a quantum dot single-photon source and an 8-mode interferometer that is fabricated using femtosecond laser-written waveguides.

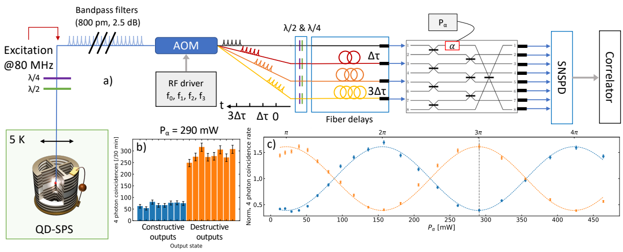

Fig. 1: (a) Simplified experimental setup to characterise 4 photon indistinguishability from a quantum dot single-photon source (QD-SPS). (b) Histogram of the number of coincidences for each output state for $P_\alpha = 290\ mW$ ($\alpha \sim 3\pi$). (c) Normalized coincidence rate of four-photon coincidences as a function of the internal phase of the interferometer.

Single-photons from a QD-SPS are separated into four spatial modes using a frequency-modulated AOM. For our cavity-embedded bright QD-SPS [3], 4-photon coincidences at the output of the interferometer are detected at a rate of 2.7 Hz. The number of four-photon coincidences as a function of the internal phase of the interferometer, α, exhibits clear interference fringes (Fig. 1c). The visibility of the interference fringes gives direct access to the four-photon indistinguishability, which is measured here to be $c_1 = 0.67 \pm 0.02$ (0.81 ± 0.03) without (with) spectral filtering and with $3\Delta\tau \sim 540\ ns$ maximum delay between photons.

References

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