Complex Temporal Mode Profiles from Time-Resolved Single-Photon Intensity Interferometry

Rory Hatfield*, Chenqi Qian, Thomas Cumming, Steve Kolthammer

Blackett Laboratory, Department of Physics, Imperial College London,

Prince Consort Rd, London, SW7 2AZ, United Kingdom

An important task in the characterisation of narrowband pulsed quantum light is determining the temporal mode profile, especially if this comprises multiple modes. Schemes involving homodyne and dual homodyne detection have shown how to reconstruct the real part of and the fully complex temporal mode profile respectively [1, 2]. We show that by using a detuned continuous-wave local oscillator (LO) that we can simplify those schemes to require just one balanced detector or one pair of single-photon counting devices, without needing to lock the relative phase of the LO and signal.

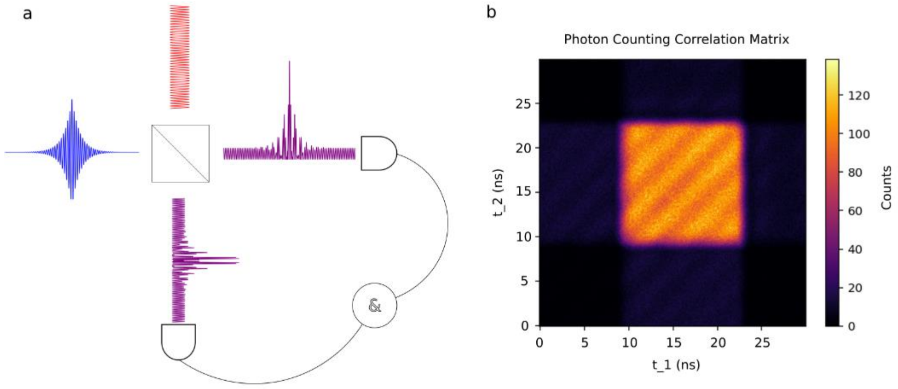

Fig. 1: *a) Schematic of the experiment. b) Representative two-photon temporal correlation data.*

Figure 1a shows an illustration of the experimental set-up. A signal pulse (blue) interferes with a detuned continuous-wave weak coherent state (red), and the outputs are measured with time-resolving single-photon detectors. Figure 1b shows an example correlation matrix of two-photon detection events measured from many trials, over which the relative phase of the signal and LO need not be stable. Interference fringes over the square pulse shape appear at the beat frequency between the signal and LO. Demodulation and convolution of these data extracts the temporal first order coherence matrix, the diagonalisation of which gives the temporal mode profile.

We demonstrate our method using SNSPDs and time-tagged detection to estimate the temporal mode profile of few-ns signal pulses. Further, we show how these methods can be adapted to measure the twin-field joint temporal amplitude of multimode light from spontaneous parametric down-conversion, despite the LO not being phase-locked to the signal.

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**rory.hatfield23@imperial.ac.uk*

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