Generation, Detection and Characterization of Photonic Quantum States

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The first part of the talk is about witnessing quantum non-Gaussian (QNG) properties of single-photon and multiphoton light using multi-channel detectors. QNG is a quantum property of photon-number states, which stands between nonclassicality and Wigner function negativity. First, we measured the QNG loss tolerance of heralded single-photon states generated by parametric processes and quantum dots [1]. Then we generated multiphoton light in multiple heralded modes, and verified QNG for up to 9 photons [2]. Finally, we generalized the concept of QNG, focusing on genuine presence of higher photon-number states, and witnessed *genuine* QNG of the first to third order [3].

The second part presents experimental ways of generating given photon statistics and temporal correlations. We employed a programmable intensity modulation and a simple Mandel formula inversion to obtain any given classical photon-number distribution p_n [4]. We demonstrated an accuracy of $\delta p_n < 10^{-3}$ and generation of a heavy-tailed distribution for up to 500 photons. Then, we proposed two methods of intensity modulation to obtain a given shape of the $g^{(2)}$ auto-correlation [5]. The first method was demonstrated experimentally to yield general cross-correlation shapes. The second method only permits convex shapes, but features independent tailoring of both photon statistics and temporal correlations.

The third part is dedicated to metrology of single-photon detectors. We formulated a detailed point process model for actively quenched single-photon avalanche diodes and verified it experimentally [6]. While we reached record precision in modelling the counting statistics, we also discovered unknown non-Markovian or non-stationary behaviour. In the most recent work, we demonstrated a direct single-source method for measuring nonlinearity of single-photon detectors [7]. The results identified new supra-linear regimes for both avalanche diodes and superconducting nanowires.

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