Towards a standard procedure for the measurement of the multi-photon component in a CW telecom heralded single-photon source

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Because of their upcoming widespread dissemination, the need for the characterization and standardization of single-photon sources is becoming of the utmost importance. Here we illustrate a strategy to provide an estimate of the multi-photon component of a single-photon source, and we show the results of a pilot study [1] for the measurement of the second-order autocorrelation function $g^{(2)}(0)$ of a low-noise CW heralded single-photon source [2, 3].

The single photon source is composed of a CW laser ($532\,ns$) that pumps a PPLN crystal, which produces non-degenetare parametric down-conversion. The idler photon ($810\,ns$) heralds the presence of the signal photon ($1550\,ns$) which is fiber-coupled and sent to an electro-optical shutter (OS) controlled by a field-programmable gate array (FPGA). At each heralding photon detection, the OS opens for a time span $\Delta t_{switch} = 7\,ns$ in correspondence of the passage of the $1550\,ns$ heralded photon. For the purpose of this joint measurement, the source output is then connected to a $50-50$ fiber beam splitter (FBS), whose outputs are sent to two different Hanbury Brown and Twiss (HBT) interferometers, each composed of a $50-50$ FBS connected to two InGaAs-InP single-photon avalanche diodes (SPADs). Three different configurations of detectors and coincidence electronics are then compared.

The single-photon component is estimated by Glauber's normalized second order autocorrelation function $g^{(2)}(0)$, approximated, in our case, by the parameter:

$$\alpha = \frac{P_{12}^{(Ph;Ph)}}{P_1^{Ph} P_2^{Ph}}, \tag{1}$$

where $P_{12}^{(Ph;Ph)}$ is the probability of a coincidence count between the two SPADs of the same HBT (dark counts subtracted).

The results of this study (involving three metrological institutes, i.e. INRiM, NPL and PTB), carried with three different measurements setups and data collection methodologies, are all in agreement with each other within the experimental uncertainties. The proposed strategy will help to build a robust and unambiguous procedure for the characterization of the emission of a single-photon source, a task of the utmost relevance for metrology for quantum technologies.

References

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