Frequency Up-Converted Single Photons

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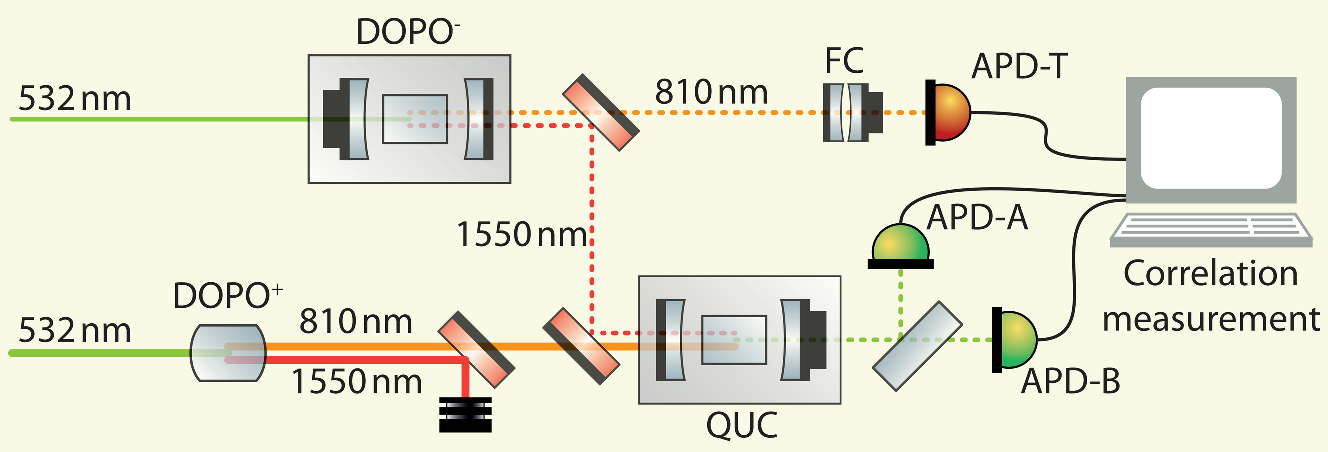
Abstract

Nonclassical states of light are an important resource in today's quantum communication and metrology protocols. A very useful tool in this field is **quantum up-conversion** [1] of nonclassical states. It bridges the gap between the efficient generation of the states and the operating wavelength ranges of quantum memories or measurement apparatus.
Here we present the production and detection of heralded narrow-band single photons at 1550 nm via cavity enhanced spontaneous parametric down-conversion with subsequent up-conversion.

RESULTS PUBLISHED SOON

Single photon up-conversion



Two doubly resonant optical parametric oscillators are pumped above ($DOPO^+$) and below ($DOPO^-$) oscillation threshold.

The 1550 nm photons are up-converted to 532 nm in the quantum up-conversion (QUC) cavity.

The 810 nm heralding photons are spectrally filtered (FC).

State analysis is done in a Hanbury Brown and Twiss setup with Si-APDs.

Temporal correlations and $g^{(2)}(0)$

RESULTS PUBLISHED SOON

The histograms of detections at APD-A (red) and -B (orange) are shown as well as the theoretical curves. The coincidence events are shown in green dots and refer to the right y-axis. The theoretical curves are given by:

γ=*FWHM of DOPO⁻*$=\pi$ 31 MHz, ϵ=*gain parameter,* $\mu=\gamma+|\epsilon|$, $\lambda=\gamma-|\epsilon|$, κ=*FWHM of extra filter*$=1.4\gamma$

$$g^{(2)}(0) = \frac{2(1-p_0-p_1)}{[2(1-p_0)-p_1]^2}$$

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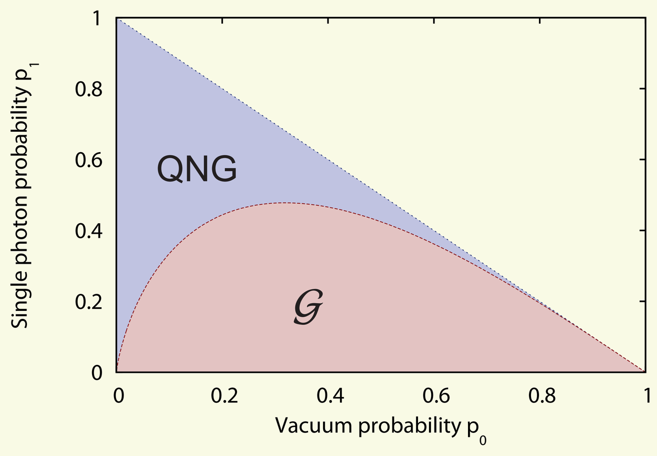
Quantum Non-Gaussianity

All Gaussian states and mixtures thereof form a convex set $\mathcal{G}$. Any state which is not in G is defined to be quantum non-Gaussian (QNG).

For a given (measured) vacuum probability p_0 a maximum single photon probability p_1 for the state to be a Gaussian state can be calculated. If the measured p_1 is higher, then $\rho \notin \mathcal{G}$ [2,3].



It is also possible to define a witness of quantum non-Gaussianity, which can be expressed in numbers of standard deviations while assuming Poissonian statistics of the measured photon rates.

RESULTS PUBLISHED SOON

The witness of QNG is plotted against the size of the acceptance window and three different gain parameters ϵ.

Conclusion

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The technique presented here might enrich the research in quantum communication as it brigdes the gap of transmitting infrared single photons through optical fibers and then up-convert and store them in quantum memories. As the up-conversion is tunable in principle by several tens of nanometers, optical transitions of atoms, ions or molecules should be possible to address.

Recently, in a similar setup quantum up-conversion of squeezed vacuum states of light was shown with 1.5 dB shot noise suppression at 532 nm [4].

References

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