Quantum Properties of Twin Beams in Cascaded Quadratic Processes

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Abstract: We report on the characterization of the quantum properties of twin beams generated through cascaded processes in quadratic cavities. The experimental scheme has been updated to observe phase anti-correlation and entanglement.

Twin beams (TBs), such as those generated by parametric down-conversion, exhibit strong intensity correlation and correspondingly phase anti-correlation, leading to squeezing both in their intensity difference [1] and in the phase sum observable, and to entanglement between the two fields [2]. The availability of TBs sources made it possible to implement quantum communication and computation protocols with continuous variables, as well as to improve the precision of measurements beyond the shot noise limit [3,4].

We report on the state of the art of our experiment, conceived for the observation of quantum properties of TBs generated through cascaded second harmonic generation and optical parametric oscillation in a doubly resonant second harmonic cavity [5,6]. According to theoretical predictions the complex interactions between cascaded second order processes lead to a variety of nonclassical effects that are not accessible via each single nonlinear process [7].

While nonclassical intensity correlations have already been observed, the current work is focused on the realization of a scheme able to demonstrate the entanglement of the TBs. In fact, bipartite continuous variable entanglement can be tested according to a criterion established by Duan, based on the total variance of EPR-type operators. To apply this inseparability criterion, a simultaneous measurement of the variances of combinations of quadratures, i.e. the amplitude quadratures difference and phase quadratures sum of the TBs, is required [8]. To measure phase quadrature variations we plan to adopt a self-homodyne scheme without the use of external local oscillators, and to exploit the dispersive character of a cavity resonance to achieve the conversion of phase to intensity fluctuations. Also, in order to detect the predicted antisqueezing of the observables, we exploit an optical cavity acting as a passive low pass filter, finally realizing a shot noise limited source in the bandwidth of interest.

References

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