TRR 142
Tailored Nonlinear Photonics

TRR Guest Scientist Lecture / Seminar

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Tailored Non-Gaussian Multimode States

Abstract:

In an all-optical setting, there are various approaches to quantum information protocols, often classified according to the way information is encoded and measured. The discrete variable approach relates to single photon or photon number resolving detectors, while the continuous variable approach (CV) implies homodyne detection to access the quadratures of the electromagnetic field. The major advantage of the latter is the deterministic generation of quantum resources, e.g., entanglement between up to millions of modes [1]. Such multimode entangled states, however, remain Gaussian, which implies that their CV properties can be simulated using classical computational resources. Hence, if a quantum information protocol is to manifest a quantum advantage, it requires non-Gaussian operations, which can be implemented incorporating single-photon addition or subtraction to a purely CV scheme [2]. In order to scale up CV quantum information approach it is then necessary to combine de-Gaussification techniques to multimode squeezing sources.

Using a source of multimode squeezed states based on parametric down conversion of an optical frequency comb [3], we implement photon subtraction on a coherent superposition of time/frequency modes [4]. This is achieve using a sum-frequency process between the quantum source and an intenses gate beam. Full control on the gate beam time/frequency modes governs the modal decomposition of the process. Single photon detection on the sum-frequency beam heralds the generation of a multimode non-gaussian beam. State tomography is performed via homodyne detection, where the local oscillator beam is pulse shaped in order to achieve mode-dependent quadrature measurement.

We demonstrate that negative Wigner function states can be obtained, choosing which of the eigenmodes of the quantum source is affected by the de-gaussification (see figure). Furthermore, in this multimode scenario, mode dependent detection allow for the generation of graph-states [5]. We study the effect of coherent photon subtraction onto these graph states [6, 7] and demonstrate experimentally that the non-gaussian characters induced by photon-subtraction spreads along the graph state, but that the spread is fundamentally limited by the nature of these states. This can serve as a guide to tailor large-scale non-Gaussian states for quantum information processing.

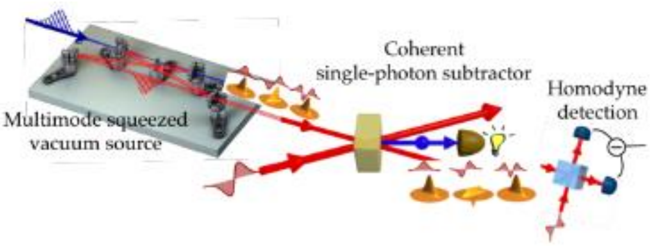

Figure 1: *Experimental Setup: controlled coherent singlephoton subtraction from a multimode squeezed vacuum source induces the generation of a multimode nongaussian graph state. State tomography is performed via time/frequency mode dependent homodyne detection.*

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