# Nonclassicality and quantum non-Gaussianity of photon-added/subtracted multi-mode Gaussian states

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Gaussian states are prominent in continuous-variable quantum information but non-Gaussian states or operations are essential for performing certain quantum information tasks. Nevertheless, for a state to be nonGaussian is not always enough for it to be interesting in the context of quantum information or quantum computing tasks. Indeed, non-Gaussian states may still be classical meaning that they may be mixtures of coherent states. Or they may be more generally mixtures of Gaussian states, in which case they are said not to be quantum non-Gaussian. Nonclassicality or the stronger property of quantum non-Gaussianity are needed for certain quantum informational tasks and a variety of techniques for their detection and measure have been developed. One possible method for producing non-Gaussian states is through photon addition or subtraction from a Gaussian state. In this talk, we provide a quantitative analysis of the degree to which the resulting states are nonclassical or quantum non-Gaussian. For our analysis, we will concentrate on two distinct measures of nonclassicality, namely their quadrature coherence scale (QCS) [2] and their Wigner negativity, as expressed through their Wigner negative volume [4]. Regarding the quantum non-Gaussianity, we will use a sufficient criterium on the value of the Wigner function at the origin, developed in [1]. Our results for single-mode states establish that the degaussification through photon addition/subtraction does substantially enhance the nonclassical features of the underlying Gaussian states. Importantly, these results also entail that the increased nonclassicality that is generated in the process comes at a cost. Indeed, the QCS is proportional to the decoherence rate of the state so that the resulting states are considerably more prone to environmental decoherence. Our results are quantitative and rely on explicit and general expressions for the characteristic and Wigner functions of photon added/subtracted single- and multi-mode Gaussian states for which we provide a simple and straightforward derivation. These expressions further allow us to identify a family of photon-subtracted Gaussian state with positive Wigner function that are quantum non-Gaussian. This talk is based on [3].

## References

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