Phase-space inequalities: theory and experiment

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The identification and characterization of nonclassical states of light is a central task in quantum optics and photonic quantum information. Nonclassicality as a resource is of major importance for quantum technologies such as quantum metrology, communication, or entanglement generation. One possibility of identifying genuine nonclassical features is using the framework of quasiprobability distributions [1]. Alternatively, inequality conditions based on moments of observables can be used [2]. We introduce a framework which unifies the certification of quantum correlations through quasiprobability distributions and inequality conditions. In this way, we demonstrate a deep connection between correlation measurements and phase-space distributions and device nonclassicality conditions which exploit the advantages of both approaches. Firstly, we derive conditions based on Chebyshev's integral inequality which relate different phase-space distributions to each other [3]. Importantly, this approach allows us to certify nonclassicality even if the involved phase-space distributions are nonnegative. Secondly, we unify the the notions of quasiprobabilities and matrices of correlation functions [4]. The method developed here correlates arbitrary phase-space functions at arbitrary points in phase space, including multimode scenarios and higher-order correlations. We illustrate the strength and practicality of the presented methods by applying them to experimental data [5]. In particular, we use different phase-space inequality conditions to certify the nonclassical character of lossy and noise single-photon states. The single-photon state is generated via heralding detection from a spontaneous parametric down-conversion source and is recorded via balanced homodyne detection. Remarkably, we can detect nonclassicality in parameter regions where other established methods fails to do so.

References

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