# Phase-space inequalities: certification of quantum correlations in the phase space


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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, and entanglement generation. Therefore, it is crucial to develop efficient and experimentally accessible tools for the characterization of nonclassical light. One possibility of identifying genuine nonclassical features is using the framework of quasiprobability distributions. Alternatively, inequality conditions based on moments of observables can be used. We introduce a framework that unifies the certification of quantum correlations through quasiprobability distributions and inequality conditions [1]. In this way, we demonstrate a deep connection between correlation measurements and phase-space distributions and devise nonclassicality conditions which jointly exploit the advantages of both approaches. Our method correlates arbitrary phase-space functions at arbitrary points in phase space, including multimode scenarios and higher-order correlations [2].

In addition, we present experimental implementation of the introduced phase-space inequalities for nonclassicality certification [3]. We demonstrate the practicality and sensitivity of this approach by studying nonclassicality of a family of noisy and lossy quantum states of light.
To this end, we experimentally generate single-photon-added thermal states with various thermal mean photon numbers and detect them at different loss levels. Based on the reconstructed Wigner and Husimi Q functions, the inequality conditions detect nonclassicality despite the fact that the involved distributions are nonnegative, which includes cases of high losses (93%) and cases where other established methods do not reveal nonclassicality. We show the advantages of the implemented approach and discuss possible extensions that assure a wide applicability for quantum science and technologies.

## References


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