Metrological witness for non-Gaussian quantum entanglement

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Major efforts are being conducted worldwide for harnessing the power of quantum systems for information processing and computation. Quantum states of light offer a promising candidate platform for those efforts. The latter is due, among others, to their strong resilience to decoherence and its potential for scalability.

Within the framework of continuous variable quantum systems, states can be described by means of quasi-probability distributions in phase space, notably through the Wigner function. It is known that a non-Gaussian statistics with a negative Wigner function, together with quantum entanglement [3], is necessary to develop protocols that can not be simulated efficiently with classical resources. In particular, it has been shown in [1] that not passive separable states, i.e., non-Gaussian states whose entanglement cannot be undone by passive linear optical operations - and, thus, are entangled in all mode bases, is needed to reach a quantum advantage in a class of sampling protocols.

In recent years, a connection between quantum correlations and metrological power, described through the quantum Fisher Information, has been exploited to propose an efficient witness for entanglement [2]. Based on this result we propose a basis independent method to witness this particular form of non-Gaussian entanglement, it is, to witness entanglement that can not be undone by passive operations.

We will show that we can use this witness to characterize not passive separability in one and two-photon subtracted states, which are within the reach of current experiments. We will then discuss the effect of losses on the ability of the criterion to work on those states, and show that we find a strong resilience to losses, of up to 50%. This resilience encourages us to find a feasible protocol to test this witness on real experiments.

References

[1] U. Chabaud and M. Walschaers. Resources for bosonic quantum computational advantage. *Phys. Rev. Lett.*, 130:090602, Mar 2023.

[2] M. Gessner, L. Pezzè, and A. Smerzi. Efficient entanglement criteria for discrete, continuous, and hybrid variables. *Phys. Rev. A*, 94:020101, Aug 2016.

[3] A. Mari and J. Eisert. Positive wigner functions render classical simulation of quantum computation efficient. *Phys. Rev. Lett.*, 109:230503, Dec 2012.