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Detecting entanglement from work extraction

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Whereas correlations among the constituent parts of a quantum system are often described from an information theoretical perspective, Quantum Thermodynamics provides an alternative framework for the certification and quantification of entanglement in terms of potential work extraction.

In this work we investigate the relationship between separability and ergotropic gap in Continuous-Variable systems, more specifically within the restriction to the Gaussian bipartite case. We identify important differences with respect to de DV case, arising as a consequence of the infinite-dimensional nature of the Hilbert space. Moreover, we derive a bound on the maximum relative ergotropic gap (relative with respect to the global passive state's energy) for separable mixed states, which turns this energy-related quantity into a valid entanglement witness. Finally, we identify a parametric family of Gaussian states for which the violation of our bound constitutes not only a sufficient, but also a necessary condition for entanglement.

Apart from being interesting from a fundamental point of view, as an approach to bridge quantum information and statistical mechanics and to understand the role of quantum correlations in both contexts; our results pave the way to new schemes for entanglement detection, which could potentially be less resource-consuming than the traditionally-used quantum state tomography. Furthermore, since entanglement is a crucial resource both for information processing and energy processing, understanding how thermodynamical quantities can reveal entanglement is key to optimize heat transfer, work extraction, and performance of thermal machines.

Theme

Theme 3. Theoretical and experimental methods for quantum effects in energy processes

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