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Quantum correlations relativity for continuous variable systems

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It is shown that a choice of degrees of freedom of a bipartite continuous variable system determines the amount of non-classical correlations (quantified by discord) in the system's state. Non-classical correlations (that include entanglement as a special kind of correlations) are ubiquitous for such systems. For a quantum state, if there are not non-classical correlations (quantum discord is zero) for one, there are in general non-classical correlations (quantum discord is non-zero) for another set of the composite system's degrees of freedom. The physical relevance of this "quantum correlations relativity" is emphasized also in the more general context.

entanglement, non-classical correlations, quantum discord, tensor product structure

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1 Introduction

The promise of quantum information processing is the promise of quantum-information resources [1]. To this end, some surprising results and observations are possible and even expectable. The discovery of non-classical (quantum) correlations not necessarily including entanglement, as quantified by quantum discord [2,3], opens a new avenue in quantum information processing; for recent reviews see refs. [4–6]. A search for quantum information resources and the ways of their operational use is at the core of the current theoretical and experimental research [4–8] (and the references therein).

Entanglement relativity is a corollary of the universally valid quantum mechanics that states [9–15]: for a composite (e.g., bipartite) system, there is entanglement for at least one structure (one set of the degrees of freedom) of the composite system. The structures are mutually related by the proper (e.g., the linear canonical) transformations of the composite system's degrees of freedom; paradigmatic are the composite system's center-of-mass and the "relative (internal)" degrees of freedom. In practice, it means: if a quantum state is separable (no entanglement), just change the degrees of freedom and entanglement will appear [10,12,13]. Quantum entanglement is ubiquitous as a quantum information resource.

In this paper we consider the continuous variable (CV), including open, quantum systems with an emphasis on their bipartitions. Based on entanglement relativity, we point out relativity, i.e., structure (degrees of freedom) dependence, of the more general non-classical correlations quantified by quantum discord. Likewise entanglement, the more general non-classical (quantum) correlations are also structure-dependent and ubiquitous in quantum systems.

So we conclude: There are non-classical correlations (not necessarily including entanglement) for practically every quantum state of the systems relative to some structures.

In sect. 2, we briefly outline entanglement relativity. In sect. 3 we derive our main result. Sect. 4 is discussion placing our considerations in a more general context and we conclude in sect. 5.

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