Description for general public: Role of quantum coherence in quantum technology

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The superposition principle of quantum mechanics states that given two different quantum states of a system, any linear combination of these states also gives rise to a valid quantum state. Quantum coherence is a direct result of this principle: given some fixed basis, any nontrivial superposition of the basis states leads to coherence. While this concept clearly depends on the choice of the basis, in many realistic situation such a basis is singled out by the unavoidable decoherence.

Very recently, it was realized that coherence can be seen as a resource in several quantum technological tasks [1, 2]. In particular, if an experimentalist has limited capabilities in the lab, i.e., if she or he can only perform manipulations which do not create coherence, then quantum states with a large amount of coherence become a resource. In several recent papers, the role of coherence for quantum state manipulation has been discussed [1, 2, 3]. In this context, it is important to consider distributed scenarios, where two or more parties are spatially separated, but have access to a classical channel (such as a telephone). So far in quantum information theory one usually assumed that in those distributed scenarios local manipulations of the systems can be performed at no additional cost. The corresponding framework is known as local operations and classical communication [4]. However, if local coherence is considered as a resource, this framework is not suitable any more, and new tools have to be developed. First steps in this direction were made in [5, 6], leading to the framework of local quantum-incoherent operations and classical communication. This framework has been successfully applied [7] to define and study the incoherent version of quantum state merging [8, 9], which is one of the most important tasks in quantum information theory.

In this project, we will develop these tools further, especially aiming to find a full solution for incoherent quantum state merging. We will also apply our framework to other tasks such as quantum state redistribution [10]. We will further study the interplay between coherence, entanglement, and quantum discord, which is an alternative quantifier of nonclassicality different from entanglement [11, 12].

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