Measuring quantum correlations of two qubits coupled to photon baths in terms of population inversion

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Coherent superpositions in quantum mechanics give rise to correlations between the parts of a given system [1, 2]. Such correlations can be classic or quantum, and both of them may coexist for a given system [3]. Entanglement was proposed as a manifestation of quantum correlations [2], though not all quantum correlations are associated to entanglement since separable states can be quantum correlated [4, 5] (see also [6, 7]). Diverse measures of entanglement have been introduced over the time, examples are the concurrence [8, 9] and the negativity [10]. More general measures, as the quantum discord [11–13], quantify quantum correlations without the requirement of entanglement.

In this contribution we analyze the time-evolution of the correlation between two qubits that are coupled to two independent photon baths. It is assumed that the systems qubit+bath are one isolated from the other; that is, they are in cavities for which no communication is allowed. In this form, each qubit interacts with its environment (the photon bath) and decoherence results. The initial correlation between the qubits is then lost and recovered in time by time because the entire system is closed. We investigate the coherences of the entire system (two qubits, two photon baths) that are missed when information of one of its subsystems (the qubits) is required by summing up (partial tracing) over the degrees of freedom of the other parts (the photon baths). Such coherences include information of conditioned transitions between the states of the entire system that is lost, in a first sight, as a consequence of looking at the subsystems. However, this information can be recovered by analyzing the state of the parts in proper form. Indeed, we shall show that the study of the population inversion of the qubits represents a measure of quantum correlations that is in agreement with the concept of concurrence.

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