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Investigating the entanglement between single-atom and multi-photon double-cavity using deformed Janes -Cummings model

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Abstract

In this research, we investigate the entanglement between two cavities, each consisting of a two-level atom and a deformed multi-photon field. The model used in this study is the deformed Jaynes-Cummings (DJC) model. A physical interpretation of the introduced model is that there are two separate cavities with Kerr-like environments, each containing a two-level atom and a non-deformed multi-photon field, where each atom interacts locally with its corresponding field. Generally, we assume that the coupling constants between the atoms and fields are unequal, and we also consider non-zero detuning. We prove that the simple rules applicable to symmetric cavities without detuning do not hold for asymmetric cavities. We will show that the presence of asymmetric cavities and detuning are factors that can be used to control entanglement. Additionally, we examine the effects of deformed fields (Kerr-like environments) on the temporal evolution of entanglement and demonstrate that they cause the entanglement to become more oscillatory. We will show that when the sign of entanglement changes, the temporal evolution of entanglement will be completely different. We consider two different initial states of the system and show that the temporal evolution of entanglement will differ for these two states. In fact, the temporal evolution of entanglement depends on the initial state of the system. To measure the entanglement, we use the concurrence parameter, where a value of one indicates maximum entanglement and a value of zero indicates no entanglement. We will also show that an initial maximum atomic entanglement can be transferred to another pair of qubits, and the type of this qubit pair depends on whether the ratios of the coupling constants are even or odd. We demonstrate that for odd ratios of coupling constants, the initial maximum atomic entanglement can be completely transferred to the fields at a specific time.

Keywords: deformed Janes-Cummings model, entanglement, detuning, concurrence parameter, coupling constant

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