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Nonlocality, entanglement and quantum teleportation for mixed spin-$\frac{1}{2}$ states

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Abstract

The violation of Bell's inequality in quantum mechanics implies that there exist nonlocality and entanglement. When the density matrix of a composite system cannot be written as a convex combination of the product of the density matrices of its subsystems, we say there exists entanglement. For pure states, the existence of entanglement always leads to the violation of Bell's inequality. However, in the case of the mixed states, there may be entanglement, but Bell's inequality is not violated and in other words, the nonlocality is not manifested. In addition to Bell's inequality, quantum teleportation is also a manifestation of nonlocality. Quantum teleportation using entangled states is more successful than quantum teleportation with separable states. Therefore, the corresponding fidelity of teleported state with the initial state (in short, the fidelity) of the former is always greater than the fidelity of the latter. In this paper, for Werner's state, we will show that in a range of the related parameter, while the CHSH inequality is violated, the fidelity, which indicates the amount of success of quantum teleportation, is lower than the upper bound of the corresponding fidelity for states that can be simulated with a local hidden variable theory. Meanwhile, we will see that for Gisin's state with hidden nonlocality, filtering, which leads to the appearance of nonlocality and more specifically leads to the violation of the CHSH inequality, also increases the fidelity.

Keywords: Entanglement, Nonlocality, Quantum Teleportation, Hidden Nonlocality, Mixed states

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