Protection of an unknown quantum state against decoherence via weak measurement and quantum measurement reversal

Abstract

As quantum bit is a basic unit of quantum computers, so its preservation against decoherence is a major task in quantum information theory. We study the dynamical behaviour of a qubit when it interacts with the environmental noise mainly with amplitude damping, itis subjected to decoherence. We calculate the trace distance between two density operators in the maximum decoherence limit.The weak measurement and measurement reversal effects before and afterdecoherence are also studied, and we found that trace distance in this case is decreased as we increase the weak measurement as well as reverse measurement strength. The success probability, the transmittance also decreases with the strength of weak measurement.

Idea of the work

The main purpose of this work is how to protect the qubit from environmental noises. It is a very good idea to adopt the distance measures such as trace distance, fidelity which quantify how close two quantum states are. Both are static measures of distance.in our proposal we take the trace distance as a measure. We begin by considering single qubit quantum state and examine its behaviour in two distinct steps:

Step 1-qubit system is subjected to decoherencechannel.

Step2-weak measurements, which collapses the quantum state partially and reversibly, and measurement reversal is applied before and after decoherence respectively.

In both the steps we got a new state, and estimating the trace distance between the original state and the final state found by step1, and step 2 separately. We found thatunder weak measurement the trace distance remains constant when we assume that decoherence is minimum. And we also calculate trace distance for different measurement strength at particular a magnitude of decoherence and found a relationship between measurement strength and trace distance which shows that trace distance decreases as we increase partial collapse measurement as well as measurement reversal.

Results

From this theoreticalwork we found thatwhen the strength of weak measurement in increasedthe trace distance is decreased which shows reduction of decoherence. Since trace distance tells us the closeness of two quantum states and a decreasing trace distance shows that the two quantum states are very close to each other. For maximum weak measurement as well as measurement reversal the trace distance comes out to be equal to zero. The success probability is also examine and we found that it was also decreased as we increase the weak measurement and measurement reversal. Our studyshows that weak measurements are reliable for fighting against decoherence.

Impact on quantum information and quantum communication

Principle of quantum superposition states that two bits are superposed to give a quantum bit which has a huge information within. But when a qubit is observed we get only either 0 or 1.Measurement changes the state of a qubit collapsing it from its superposition of $|0\rangle$ and $|1\rangle$to the state consistence with the measurement result.Measurement of quantum states is a biggest problem of quantum information theory. Such a collapse is called quantum decoherence. For real world quantum computing its suppression is important. A qubit is used in quantum computation, quantum teleportation, quantum superdense coding.So with the help of weak measurements and reversal measurement it is possible to control decoherence produced by amplitude damping and we can find quantum state which is decoherence free and applicable to perform various tasks in quantum computing and quantum information theory. The impact of present work in quantum information theory is that if we apply weak measurement and measurement reversal operation on a single qubit before and after decoherence respectively, we can reduce decoherence.

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