Observation noise

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Abstract: When a qubit interacts with environment, it may, instead of lose coherence, be observed. As is well known in quantum cryptography, such observation destroys entangled state causing noise, in this letter, called "observation noise". As quantum error correction fundamentally depends on entangled states, the observation noise makes error correction impossible. As such, quantum computation with practically large quantum parallelism is impossible. Classical computers are better than quantum ones.

1. Introduction

Quantum error correction [1] was considered to make fragile quantum states less fragile, by, instead of having multiple copies of a qubit, which is impossible, using entangled state involving multiple qubits. That is, from a qubit state of $a|0\rangle + b|1\rangle$, for example, instead of generating a 3 qubit state of $(a|0\rangle + b|1\rangle)\otimes(a|0\rangle + b|1\rangle)\otimes(a|0\rangle + b|1\rangle)$, which is impossible, an entangled 3 qubit state of $(a|000\rangle + b|111\rangle)$ is generated [1]. The idea was that, as distance between $|0\rangle$ and $|1\rangle$ should be 1 and distance between $|000\rangle$ and $|111\rangle$ should be 3, $(a|000\rangle + b|111\rangle)$ should be 3 times less fragile than $a|0\rangle + b|1\rangle$.

However, as our common sense is that entangled states are extremely fragile, is it really so? Is the highly entangled 3 qubit state of $(a|000\rangle + b|111\rangle)$ is less fragile than a simple unentangled superpositioned state of $a|0\rangle + b|1\rangle$?

The answer is that it depends on noise considered.

In section 2, a new kind of quantum noise called, in this letter, "observation noise" is introduced to show that, by the noise, the entangled state above can be utterly destroyed beyond any error correction. Section 3 concludes the letter. In Appendix A, it is shown that, even without noise or error, classical computers are faster than quantum ones.

2. Observation noise

In quantum cryptography [2], it is well known that observation by an eavesdropper destroys entangled state, which is detected as noise by a legitimate receiver. In this letter, such noise is called “observation noise”.

In quantum computing, a qubit consisting a 3 qubit state of $(a|000\rangle + b|111\rangle)$ interacting with environment may, instead of lose coherence, be observed to be $|0\rangle$. Then, the observation changes the quantum state from $(a|000\rangle + b|111\rangle)$ to $|000\rangle$, totally losing information on a and b. That is, entangled states are extremely fragile and quantum error correction fundamentally depending on entangled states is, against observation noise, impossible.

3. Conclusions

By introducing new kind of quantum noise of “observation noise”, caused by destruction of entangled states by observations, it is shown that quantum error correction fundamentally depends on entangled states is impossible against observation noise.

Observation noise is a powerful concept to explain why entangled states are extremely fragile and applicable to various cases. For example, it is obvious that observation noise badly interferes quantum annealing processes [3].

As such, practical scale quantum computing is impossible.

Appendix A discusses, even without noise or error, classical computers is faster than quantum ones. Thus, in both theory and practice, classical computers are better than quantum ones.

References

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Appendix A. Ideal classical computers can be arbitrarily fast

As classical computers are not annoyed by quantum effects such as size of atoms, which limits machining accuracy, or a unit of electric charge, which limits minimum signal current through shot noise, if there is no other cause of error or noise, there is no limitation applying Denard's scaling law [4]. We don't have to wait years for size reduction of 1/2 by Moore's law [5]. So, if there is a problem of size S requiring, say, $O(2^S)$ time to solve by a classical computer and S is given, by reducing size, voltage and current of the computer 2^{-S} times, clock can be made 2^S times faster [4] and the problem is solved in O(1) time. 2^S can be more quickly increasing function of S such as 2^{2^S}. As ideal quantum computers with N qubits suffers from $O(\sqrt[3]{N})$ propagation delay (size of atoms limits shrinking), classical computers are faster than quantum ones. On such computers, all the classical algorithms work as are.