On the hypothesis of the fundamental impossibility of creating an ideal quantum computer, connected with the hypothesis resolving the paradox of retrocausality in quantum eraser experiments.

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Abstract

The article proposes a hypothesis that resolves the paradox of retrocausality in the quantum eraser experiment. If this hypothesis is correct, its consequence will be the impossibility of creating an ideal quantum computer, that is, one in which a few shots are sufficient to execute a single quantum algorithm, for example Shor's. That is, if the hypothesis is correct, the necessity of performing a large number of runs of a single quantum algorithm will not be circumventable by solving technical problems.

Keywords:non-locality, quantum computers.

Work in the field of quantum computing has been ongoing for more than decades, yet the obstacles that arise raise the question of whether a fundamentally ideal quantum circuit of a quantum computer is possible, or at least a reasonable approximation to such a circuit, in which external disturbances and decoherence are absent. That is, an implementation in which qubits behave strictly according to the laws of linear algebra, and logic gates are performed with high accuracy. In such ideal circuits, a single repetition is sufficient to execute a quantum algorithm. It is believed that there are no fundamental obstacles to building such a quantum computer, and the achievable parameters are cited as 5- 10 repetitions (shots) per computation, for example of Shor's algorithm, and the timelines for creation assume the coming decades. But the difficulties in creating such devices suggest the impossibility of building such an ideal quantum computer for some fundamental reasons. In particular, on real quantum processors (NISQ), quantum algorithms are run in series from several hundred to several thousand runs (shots) [1]. In building quantum computers and quantum cryptography, the assumption is made that measuring one of the entangled particles instantly leads to a change in the states of the other entangled particles. That is, quantum connection is assumed only for pairs of entangled particles. This is a natural assumption under the condition that the assumption of the presence in quantum systems of memory for other previous events, of previous numerous measurements, is immediately dismissed as unthinkable. The consequence of dismissing such hypotheses is the conviction that approximation to an ideal quantum circuit is a fundamentally achievable technical task.

Meanwhile, the widely known quantum experiments on which quantum mechanics and, accordingly, the theory of quantum computers is based always presuppose the accumulation of some statistics of measurement of particle states. For example, experiments with entangled particles, the quantum eraser, and Young's double-slit experiment. In all these experiments, on the order of thousands of particles are used to accumulate quantum statistics. At the same time, ergodicity of such systems is assumed, and any assumption about the presence of memory in such systems is not considered, as supposedly impossible. Meanwhile, such an assumption could save us from retrocausality in the interpretation of quantum eraser experiments for the

case, when one entangled photon, passing through a diagonalizing polarizer and restoring the interference pattern, arrives later than the other interfering entangled photon [2]. Consider in particular the following scheme of such a quantum eraser experiment with perpendicular polarizers in a double-slit Young's scheme.

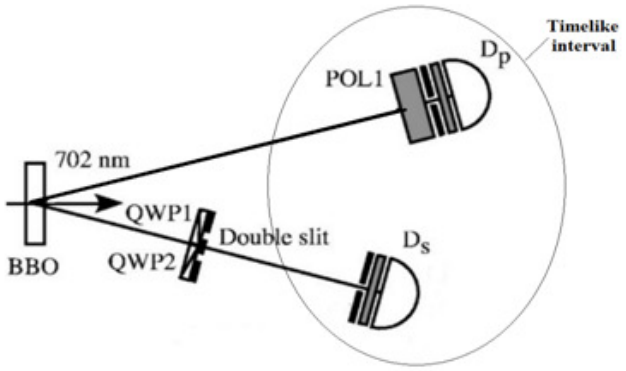

Figure 1:

Let us place a detector Ds recording the interference pattern and a diagonalizing polarizer POL1 at a time-like interval. Moreover, let the interfering photon arrive earlier than the second entangled photon passes through the polarizer POL1. Thus, in any frames of reference, the interfering photon arrives earlier, and its polarization is measured in such a way that, with such an order of measurement, interference is impossible if only the events of these two connected photons are taken into account. But since the interference pattern will be observed, this means that the interfering photon obtains information about its necessity from somewhere. Thus, we observe a picture of the fact that, to explain the interference, the cause of the event, that is, the passage of the photon through the polarizer POL1, occurs later ($t2 > t1$) than the effect of this cause. Possibly, such a paradox is connected with the obvious and natural assumption that cause and effect are almost point-like or very short events in time.

On the hypothesis of a cause "smeared" in time.

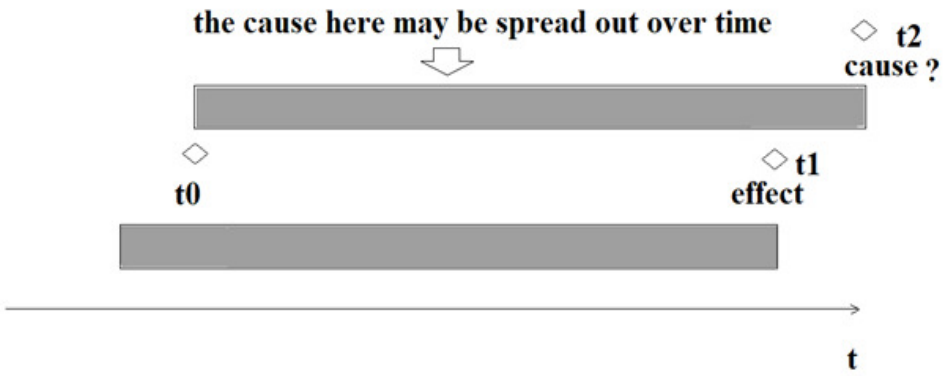

Figure 2:

If, however, we assume that the cause of each event is "smeared" in time, that is, that some event or measurement takes into account all events in the system over a sufficiently large range of preceding time and only then occurs, then the paradox of retrocausality is removed. Indeed, if, for example, some effect occurs at time t1, and the apparent cause at time t2 itself

also depends on the preceding range $(t2-t0)$ of time, then the effect at time t1 can be explained by the preceding range $t1-t0$, and the principle of causality is preserved. Namely, let the event at time t2, which we consider the cause, itself depend on events in the time range $(t2-t0)$. Then the event of the effect at time t1, by virtue of the entanglement of the particles, will also depend on these same events in the time range $(t1-t0)$ and thus will be connected with the apparent cause at time t2. Since, because of entanglement, the two particles have the same past, the particle at t1 will know how the entangled particle will behave at t2 and therefore depend on this event. Naturally, $t2-t0 > t2-t1$. Thus, it can be assumed that the information about the retrocausal interference in the quantum eraser experiment is stored in the long-term memory of the entire quantum system, which contains data about previous measurements.

Why, if the hypothesis of a cause "smeared" in time is correct, ideal quantum computers are impossible.

Suppose now that for the observation of quantum effects, including for a quantum computer, the prehistory of the quantum system is important, that is, that it must be taken into account. If an ideal quantum computer is possible, then it must be possible in several copies. Such ideal quantum computers must produce a limited set of identical results out of an infinite set of all possible ones in a few runs, for example of Shor's algorithm. But under the condition of the existence of long-term memory of quantum systems, for a limited set of results they must have an identical prehistory, which is impossible. That is, under the condition that the hypothesis of the existence of memory of quantum systems is correct, that is, the hypothesis that removes the paradox of retrocausality, the existence of ideal quantum computers is impossible. It can also be assumed, in accordance with this hypothesis, that in real quantum computers some acceptable identical prehistory is achieved by a large number of runs.

References

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