Academic Journal of
Physics Research

Juniper PUBLISHERS
key to the Researchers

Research Article
Volume 1 Issue 1 - February 2025

Academic Journal of Physics Research

Creating A Quantum Processor Based on A Top-Down Ideology-Another Possible Solution to the Problem Quantum Computer

Voronov VK*, Funtikova EA and Dudareva OV

Irkutsk National Research Technical University, Irkutsk, Russia

Submission: January 13, 2025; **Published:** February 05, 2025

***Corresponding author:** Voronov VK, Irkutsk National Research Technical University, Irkutsk, Russia

Abstract

The state of research on the problem of creating a quantum computer is discussed. In this regard, significant stages of research on this problem are named. It is noted that the idea of creating quantum computers as such was first expressed and substantiated in the works of R. Feynman, published in the eighties of the twentieth century. The necessity of creating a processor whose operation would be carried out in accordance with the laws of quantum physics is proved. Difficulties of a fundamental nature are indicated, which from the very beginning had to be overcome by creating a quantum computer. Another way to implement R. Feynman's idea to create a device that performs a computational procedure using a quantum computer is considered.

Keywords: Quantum Processes; Q-Bits; Quantum Dots; Shor's Algorithm; Nanotrigger

Introduction

The idea of creating a processor whose operation would be carried out in accordance with the laws of quantum physics was put forward and substantiated by R. Feynman in articles published in the eighties of the twentieth century [1,2]. The reason for its substantiation was the conclusion that the memory resources and speed of classical machines are insufficient to solve quantum problems. This fact can be illustrated at the qualitative level as follows. A system of n particles with two states (spin 1/2) has 2^n basis states. In the process of solving a specific problem, it is necessary to set (write to the computer memory) 2^n amplitudes of these states, as well as to carry out the appropriate calculations. Since n can in principle be a large number, the number of states with which it is necessary to operate in the process of solving the problem will also be such. Ultimately, this can lead to insurmountable obstacles in the way of computational operations. Based on this negative result, R. Feynman suggested that quantum computers would probably have properties that would allow them to solve quantum problems. To what has been said above regarding the motives for posing the problem of creating quantum computers, it should probably be added that this need is associated with the general problem of the existence of non-computable functions and related algorithmically unsolvable problems. The discussion of this issue was quite fully conducted by Y.I. Manin [3].

It should be noted that all (or almost) research carried out so far related to the creation of a quantum computer is based on the search for suitable individual quantum objects. Therefore, we can talk about the use of ideology from the bottom up. It is believed that the creation of a really working quantum processor based on such individual objects (q-bits), suitable for the implementation of the quantum counting procedure, is a matter of technique. The large mathematical resource created in this way can then be used to perform calculations. There are a number of problems along the way (in particular, scaling and decoherence problems) that prevent (at least for now) the successful solution of this problem.

Since the substantiation of the idea of a quantum computer, many different compounds have been synthesized, a lot of different materials have been created, including two-dimensional materials (the first among them is graphene). The question arises: "Is it possible to try to use them in order to create a priory the necessary mathematical resource, the elements of which, remaining within the laws of quantum physics, could be used in calculations?" implementation of the idea of creating a quantum processor. If we proceed from a positive answer, we should conclude that they should be analogues of the elements of a classical computer, i.e. they could primarily play the role of triggers. This is how we arrive at the idea from top to bottom. The rationale behind this approach is set out below. This is preceded by a description of significant stages of research, the results of which are aimed at creating a quantum computer.

Results and Discussion

As is known, a quantum computer operates with states (see review articles [4,5] and the literature cited there). The simplest system that performs a function similar to the bits in classical computers is a system with two possible states. To denote the state of such a quantum two-level system, a special term is proposed: q-a bit (qubit) - a quantum bit of information - the state of a quantum system with two possible basic states and the general state of such a system is a superposition: $|0\rangle |1\rangle$

$$|q\rangle = C_0 |0\rangle + C_1 |1\rangle$$

something more than Boolean 0 or 1; q – a bit is a quantum superposition of two numbers: zero and one! It can therefore be said that the idea of a quantum computer is based on the fact that superpositions of states are possible in quantum mechanics. A quantum system with two basic states (qubits) allows you to encode the numbers 0 and 1 in these states.

Physical systems that implement q-bits can be any objects that have two quantum states: polarization states of photons, electronic states of isolated atoms or ions, spin states of atomic nuclei, and lower states in quantum dots. A full-scale quantum computer would have to contain a large number of qubits - hundreds or even thousands - in order to actually solve real-world problems. Therefore, the state of a quantum computer is nothing more than a very complex, confusing state. Mathematically, it is described by the sum of a large and even huge number of terms. Each of these terms is the product of states of the form $|0\rangle$ or $|1\rangle$. The factors in this work describe the possible states of individual qubits in a long chain. Ultimately, the quantum principle of superposition of states makes it possible to give a quantum computer fundamentally new "ability".

The very first operation of all (classical and quantum) calculations - the preparation of the initial state of the register - demonstrates the possible advantages of quantum operations with q-bits. When typing the initial number on a classical register consisting of n bits, we need n operations - set the values 0 or 1 on each bit. In this case, only one number of length n will be written. Consisting, for example, of quantum dots, we will prepare a coherent superposition of all $Q = 2^n$ states of the general system of the quantum register. Thus, instead of one number, we will prepare 2^n possible values of the register at once a coherent superposition of all possible numbers for a given register. Naturally, this property can be used for quantum parallel computing. If we limit ourselves to a relatively small $n = 10^2$ quantum particles (q-bits), we can get a fairly large

$$2^n = 2^{100} \approx 10^{30}$$

mathematical information resource of a quantum computer. This is where the main advantages of a quantum computer come from. In fact, in the process of writing a number containing, say, n digits, that is the number of cells that will be occupied out of the total number of 10^{30}. The remaining (unoccupied) cells can be used to perform the parallel calculations mentioned above.

It should be emphasized here that these cells are not specific elements of circuits or magnetic regions (domains) on which the necessary information can be recorded. We are talking about the eigenvalues of the operator of a physical quantity that characterizes a given system of q-bits, which (values), according to the laws of quantum mechanics, can be determined with a certain degree of probability. In a sense, we are talking about a large set of virtual cells, the use of which is far from obvious. This is one of the fundamental problems. Further, after information (for example, digital) is entered into these cells, they need to be somehow managed in order to perform computational operations. And finally, you need to find a way to deduce the result after the counting procedure. From this it is easy to draw a conclusion about the fundamental difficulties that had to be overcome from the very beginning in the creation of a computer containing in its structure at least a processor that functions in accordance with the laws and regulations of quantum physics.

To one degree or another, the difficulties mentioned above still exist today. Thus, the first and perhaps the most important necessity that has appeared on the way to solving the problem of creating a quantum computer is the visualization or materialization of the above-mentioned states that are not subject to decoherence processes. Moreover, it should be borne in mind that visualization should not change reality, i.e. ensure the quantum nature of q-bit states. Such states must be specific and exist long enough for the quantum counting procedure to be successful. In fact, this means that only those quantum states that are available for visualization (materialization) are significant for the creation of a quantum computer.

By applying unitary transformations to the prepared states, which perform certain logical operations, it is possible to implement a quantum processor proper. The role of connections (wires) is played by q-bits, and the role of logical blocks (gates), into which the entire calculation process is divided, both in classical and quantum processors, is played by unitary transformations. This concept of a quantum processor and quantum logic gates was proposed in 1989 by D. Deutsch, who also found a universal logic block with which any quantum computation can be performed. In 1995, it was shown that one- and two-qubit blocks are sufficient to obtain the entire necessary set of transformations.

Relatively soon after the pioneering articles of R. Feynman regarding the need and possibility of creating a quantum computer,

How to cite this article: Voronov VK, Funtikova EA, Dudareva OV. Creating A Quantum Processor Based on A Top-Down Ideology-Another Possible Solution to the Problem Quantum Computer. Academic Journal of Physics Research. 2025; 1(1): 555555.

a whole series of theoretical studies on this topic was carried out. The result of such research was numerous publications, including reviews and monographs. Theoretical successes in solving the problem of quantum computers were based on the idea of using physical processes that would ensure the execution of logical operations similar to those in classical computers. At the same time, it was assumed that the use of the specifics of quantum objects would improve the calculation technique, but would not fundamentally change its essence. It seemed that as a result, the necessary conditions were found, the fulfillment of which should soon ensure the successful experimental implementation of Richard Feynman's idea. Moreover, the landmark work of P. Shor, published in 1994, outlined a range of real problems, the solution of which is possible only with the use of quantum computers [6]. Confidence in the imminent creation of quantum computers was largely due to the fact that already in 1998 there were works in which it was reported on the implementation of an elementary quantum algorithm using two q-bits based on the phenomenon of nuclear magnetic resonance [7,8]. despite certain experimental successes in the implementation of R. Feynman's idea, a truly quantum computer has yet to be made.

In the introduction of this work, another method for solving the problem of creating a true quantum computer was mentioned. This method is based on a top-down ideology. On this basis, it is proposed to create devices for quantum computing containing a block of triggers. Only now they should be nanotriggers, i.e. elements that function on the basis of the laws of quantum physics. Nanotriggers are created on the basis of two-dimensional materials (for example, graphene). Their number can be equal to 2^n, and the value of n will be determined by the problems for which the quantum counting procedure is supposed to be used (the size of the data array). These nanotriggers act as q-bits. However, in this case, the problem of quantum coherence is solved naturally, because they are not just quantum objects whose states need to be somehow involved in the counting procedure.

These are quantum objects that are already ready to perform counting. Nanotriggers are controlled by elements that are quantum dots acting on the principle of self-organization with two states that differ significantly in magnetic properties. Such control elements are created on the basis of a substance whose molecules are characterized by intramolecular rearrangement, for example, valence tautomerism. Further detailing of the device described in this work, which is actually capable of performing the quantum counting procedure, was carried out in publications [9,10]. It should be emphasized that the top-down method of designing a real quantum computer discussed here does not replace or cancel the bottom-up approach mentioned at the beginning of this article. This is another way to implement R. Feynman's idea of creating a device that performs a computational procedure using the laws of quantum physics.

Conclusion

The idea of creating a processor as such was put forward and substantiated by R. Feynman in articles published in the eighties of the twentieth. The reason for its substantiation was the conclusion that the memory resources and speed of classical machines are insufficient to solve quantum problems. Based on this negative result, R. Feynman suggested that, probably, it is quantum computers that will have properties that will allow them to solve quantum problems. All (or almost) research carried out to date related to the creation of a quantum computer is based on the search for suitable individual quantum objects. Therefore, we can talk about the use of an ideology from the bottom up. It is believed that the creation of a really working quantum processor based on such individual objects (q-bits), suitable for the implementation of the quantum counting procedure, is a matter of technology. On this path, there are a number of problems that impede (at least for now) the successful solution of the identified problem.

Since the substantiation of the idea of a quantum computer, many different compounds have been synthesized, and a lot of different materials have been created, including two-dimensional materials. This circumstance makes it possible (at least in principle) to use them to solve the problem of creating a quantum processor. This paper considers another way to implement R. Feynman's idea of creating a device using top-down ideology. On this basis, it is proposed to create devices for quantum computing containing a block of nanotriggers. Nanotriggers are created on the basis of two-dimensional materials. Nanotriggers are controlled by elements that are quantum dots acting on the principle of self-organization with two states that differ significantly in magnetic properties. These nanotriggers act as q-bits. These are quantum objects that are ready to perform the counting procedure.

References

1. Feynman RP (1982) Simulating Physics with Computers. International Journal of Theoretical Physics 21(6/7): 467-488.
2. Feynman RP (1986) Quantum Mechanical Computers. Foundations of Physics 16(6): 507-531.
3. Manin YI (1980) Computable and non-computable. Moscow: Sov Radio, pp.128.
4. Valiev KA (2005) Quantum computers and quantum computing. Advances in Physical Sciences 175(1): 3-39.
5. Ryabtsev II, Beterov II, Tretyakov DB, Entin VM, Yakshina EA (2016) Spectroscopy of cold Ry-dberog atoms of rubidium for applications in quantum informatics. Advances in Physical Sciences 186(2): 206-219.
6. Shor PW (1994) Algorithms for Computation: Discreta Logarithms and Factoring, Proceeding of the 35th Annual Symp. on the Foundation of Computer Science, Los Alamitos, CA, USA, pp. 124-134.
7. Jones JA, Mosca MJ (1998) Implementation of a quantum algorithm on a nuclear magnetic resonance quantum computer. Chem Phys 109(5): 1648-1653.

How to cite this article: Voronov VK, Funtikova EA, Dudareva OV. Creating A Quantum Processor Based on A Top-Down Ideology-Another Possible Solution to the Problem Quantum Computer. Academic Journal of Physics Research. 2025; 1(1): 555555.

8. Chuang IL, Gershenfeld N, Kubinec M (1998) Experimental Implementation of Fast Quantum Searching. Phys Rev Lett 80(15): 3408-3411.

9. Voronov VK, Dudareva OV, Gerashchenko LA (2020) 2D Material-based Qutum Logic Gate Operating Via Self Organization of Quantum Dots. Global Journal of Science Frontier Re-search: A 20(8): 12-20.

10. Voronov VK (2021) The Application of Generalized Rayleigh Equation for Descrition of Peri-odic Intramolecular Rearrangements, Including Valence Tautomerism. International Journal of Theoretical Physics 60(2): 924-928.

How to cite this article: Voronov VK, Funtikova EA, Dudareva OV. Creating A Quantum Processor Based on A Top-Down Ideology-Another Possible Solution to the Problem Quantum Computer. Academic Journal of Physics Research. 2025; 1(1): 555555.