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Revisiting the Possible Creation of the Quantum Information Unit-A Necessary Element of Quantum Computation Procedure

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ABCTRACT

In the present work, a previously reported idea has been further developed. The idea is based on the earlier proposed visualization of Shor's states. Therefore, the paper deals with some ideas of quantum physics, which constitute the basis of a set of the quantum objects, employed as q–bits, their possible structure and composition being disclosed. Quantum limit is implemented in cases where the characteristic of the quantum length defined by the de Broglie wavelength is equal to or lower than the physical size of the object. It is this condition should somehow be reflected in the composition and structure of the kantovyh Islands, which should serve as qubits. In other words, in the technological sense of dimensional quantum effects in this particular case, it is necessary to under-stand both the need for such facilities in the process of materializing States Shore, which would match the size (dimensions) of individual quantum islet and a critical length, describing it (the island) structure and (or) property. Also, necessary operations, performance of which at the technological level will allow for electronic unit to organize quantum computation procedure, are analyzed. It is shown that if operations with matrixes are used, the process of quantum computation can take reasonable amount of time.

Keywords: Quantum computer; Shor's cells; matrix algebra.

1 Introduction

Analysis of the state-of-the-art of quantum computations, and in particular, the problems re-lated to creation of quantum computer, shows that the current researches are mainly focused on the search for new ideas, sometimes, absolutely unexpected is put in the forefront. For this reason, our research is mainly of exploratory and, hence debatable character. They relate, first of all, to search for such molecular (multielectron) systems, the application of which should ensure the creation of really operating quantum computer [1]. Besides, one should bear in mind that over the last forty – fifty years, a huge number of new compounds with diverse physical and chemical properties has been syn-thesized and studied.

All (or almost all) researches, which have been carried out by the moment, are based on the search for appropriate specific quantum objects. It is assumed that the development of computation quantum schemes using these objects is rather routine work. In other words, the researchers try to find a solution of the quantum computer problem by studying the behavior of a small number of quan-tum objects. Figuratively speaking, the researchers try to find approaches to the solution of quantum information problem, using "from down to up" ideology. In this direction, a huge amount of work has been performed. In this connection, we should mention the recently published paper

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[2]. It is also re-ported on the methods for the preparation of materials, which could become, at least in principle, a basis for the creation of quantum computers [3]. An important feature is that the problem of quantum computer creation, if to follow the above-mentioned approach, involves mainly the search for appro-priate quantum system (or quantum systems). Creation of really operating quantum processor, suita-ble for realization of the quantum computation procedure, is a matter of technique, i.e. this is selec-tion of special conditions, for example, placing quantum objects in strong magnetic fields using NMR spectrometers.

But eventually the quantum computer, if created, represents also macroobject operating in macroworld. Therefore, "from up to down" seems also to be possible. This approach assumes that the creation of devices, suitable for quantum computations, is based on the initial application of systems containing many quantum particles and is not reduced to behavior of small ensembles composed of either already existing or specially synthesized materials. Probably, only in this case, we can use ad-vantages of the quantum computer entirely. Otherwise, taking into account great advancements in the field of modern (classical) computers development, there is no sense to invest the efforts into so-lution of the quantum computation problem. Moreover, the latter inference puts forward a problem of compatibility of the quantum computer with classical one, if to bear in mind the scale of classical computers applications and their ample opportunities. The conclusion is as follows. At the present, real quantum computer is the additional unit which is built in modern classical computers. When needed, such unit can significantly accelerate the computation procedure. However, quantum computer can also be employed in parallel computations, when this unit connected to the general system of classical computer performs calculations at some stage of the solution of a specific problem. At the same time, main units of the classical computer can solve next tasks. Apparently, it is pertinent to remember here that in the work [4], the idea (minimum program) about allocation of databank, obtained using a sys-tem of elementary quantum computers, for expansion of possibilities of Turing universal computer, has been formulated.

The paper [5] is also devoted to the above-mentioned problems. The authors analyze the state-of-the-art of experimental researches in the field of quantum computer creation and justify the idea of Shor states visualization as the first step on the way of creation of real quantum processor. The idea is based on application of the phenomenon of secondary wave generated by incident electromagnetic radiation on the object which undergoes screening. According to the theory of wave flow, the incident primary electromagnetic irradiation under certain conditions can be transformed into waves of other type, for example, surface plasmons. The massif from n quantum objects generating secondary irradi-ation, in principle, can be considered as a route to materialization of Shor cells. In other words, a sys-tem of q-bits as a base of real quantum computer can be realized in such a way.

2 Possible Functional Characteristics of Quantum Objects intended for Visualization of Shor's States

The real Shor's states are quantum-physical in essence. Therefore, the massif of quantum is-lets used for their materialization (visualization) should retain this physical feature, i.e. obey to the laws of quantum physics. It is obvious that today among such objects are heterosystems with reduced dimension or low-dimensional structures, in which the motion is limited in one, two or three direc-tions. It is well known that quantum limitation is realized when the characteristic quantum length, de-fined by de Broglie wavelength becomes equal or lower than the corresponding physical size of object. This condition should be somehow realized in structure and composition of quantum islets, which should play the role of q-bits. In other words, from technological point of view, manifestation of size quantum effects in this specific case should be understood as a need for providing of such conditions in the course of a materialization of the Shor's states, when the size (sizes) of individual quantum inlet and some critical length characterizing structure and (or) properties of this islet should coincide. For example, these are size of magnetic domains, length of free path of the charge carrier (let us say, elec-tron), optimum size of crystallites and their structure, etc. Understanding of this fact should lead to active (not passive) participation of quantum islets in the organization of calculation procedure. Correspondingly, the external effect (from macroworld) resulting in incorporation of quantum information unit in general electronic scheme of the computer operation, should have the relevant nature.

As to realization of quantum computation procedure, the process, when each materialized (visualized) Shor's cell corresponds to an element of the electronic scheme, for example, nanotransistor or nanodiode, is supposed to be the most natural. Here it should be emphasized that a trigger scheme has been already proposed. This scheme is based only on graphene ribbons of about 10 nm width, in which all elements are created due to the combination of the specified ribbons tapes, which are cut out under different angles or have different width and/or type of edge [6]. Then such elements are united in the corresponding scheme capable of performing the computation procedure. Both elements of this scheme and the scheme itself should operate according to the laws of quantum physics. Being a real quantum system, such a device performs real computation procedures similar to classical computer, but at the level of microworld.

According to the theory, the Shor's states are resulted from entanglement of q-bit states (including entanglement of quantum dots, if the latter act as q-bits). Therefore, they essentially differ from bits of the classical computer. Consequently, an ij-state can be employed in the calculation procedure over certain period of time after the states i and j will take part in the calculation. This is applicable to all ij-states which should play a role of Shor's cells. To clarify this statement let us suppose that at the given moment, for example, 5j state, i.e. the state of q-bit with i=5, is involved in the calculation procedure (j changes from 1 to m, except j = i). This means that such q-bit already ceased to be entangled with the state of q-bit (j – 1), but it is not yet entangled with the state of q-bit (j + 1). Hence it follows that implementation of the Shor's cells is defined by a strong condition, namely there should be a mechanism realized in microworld and obeyed to the laws of quantum physics, which "surveille" the states of q-bits system and ensures their entanglement when they are involved in the calculation procedure. In turn, existence of such mechanism should be somehow reflected at the macroworld level in order to one can use results of the calculation performed by the system of quantum bits (q-bits). The same problem arises also in the case of states of individual quantum points, i.e. ii-states: their involvement in the calculation procedure should be somehow ordered.

Taking into account the above remarks, the conditions for application of a massif of quantum islets (for example, 10^{10} in number) as q-bits for the organization of calculation procedure can be presented as follow. The initial moment is the assumption that such massif is incorporated into ordinary (classical) computer as separate device. At a certain stage of the computer operation, the electromagnetic radiation generated by any element of the computer excites secondary radiation, for example, plasmonic oscillations of certain frequency in quantum islets. Let there is a delay line providing for excitation of secondary oscillation in i-islet with certain delay relative to (i-1)-islet. Thus, the operation sequence of elements of the electronic device connected with a massif of quantum islets acting as q-bits will be achieved. Excitement of the secondary radiation should be accompanied by input of some initial data in order to the electronic device can perform necessary calculations. Results of the calculation can be entered into the scheme of the classical computer using a device similar to the unit which provides operation of quantum calculation.

It has been reported [5] that via simple scanning of *i* values one can obtain the cells corresponding to own values (***a_1, a_2***, …) of the ($\hat{\mathbf{A}}$) operator of physical value, which characterizes such processes in the quantum computer as, for example, current passage or wave process. At the same time, mathematical resource of the quantum computer is associated also with application of non-diagonal matrix elements, i.e. a_{ij}. If to follow this logic, this purpose requires, first, the corresponding set (massif) of quantum objects, second, comparison of the specified objects with the corresponding elements of the electronic scheme and, third, provision of consistency or sequence of usage of the quantum objects constituting other massif.

Formation of another massif of quantum objects for the purpose of visualization is not obligatory at all, if to use their combination. According to the laws of quantum physics, if the system consists of n two-level q-bits, it generally represents superposition of 2n basic states. From this fact follow the main advantages of the quantum computer (see, for example, [7]). If to be limited by rather small amount of quantum particles ($n = 10^2$), one can obtain quite large big mathematical information resource of the quantum computer.

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

This is the number of Shor's states, visualization of which is described in the present paper. The massif from 10^{10} islets and their combination by two allows reaching this purpose (at least, in principle). If to start from the fact that both individual quantum islets and their combinations by two will be involved in the operation, it is needed that secondary radiation would contain another frequency, which should ensure the application of ij-states for realization of calculation procedure. Naturally, in this case, it is necessary that the sequence of such states usage would be provided (in our case, 10^{20}).

Further specification of the possible unit for quantum computation will be connected with selection of chemical composition and molecular structure of the material, from which quantum islets should be prepared. The compounds with unoccupied 3d-, 4f- and 5f-shells are supposed to be appropriate for this purpose. Peculiarities of their electron and spatial structure of such compounds are mainly defined by interelectron correlations. Of special importance are paramagnetic complexes, which are characterized by intramolecular rearrangement, so-called valence tautomerism. Qwing to this rearrangement, molecular states with essentially different magnetic properties can be realized. If, for example, there are two such states, in the from 10^{10} quantum objects, one of these states will be present in every period of time $5 \cdot 10^9$, and approximately the same amount in the second state (at room temperatures). The specified states can be used for the number coding (for example, zero and unit) [1, 8].

All the above-stated concerning visualization of the Shor's states and specific characteristics of the quantum islets used for this purpose (of course, in the most general view) can be considered as physical modeling of these states. This modeling can be used for organization of quantum computation procedure, i.e. the problem can be solved at the technological level. In its turn, it is logically to pass from this technological level to, figuratively speaking, the mathematical description or representation. The two massifs discussed above (individual quantum objects and their combination) can be presented as two matrixes. Therefore, at some stage of the calculation procedure, these matrixes can be subjected to mathematical operations, thus expanding computing opportunities of the quantum unit. Indeed, operation with two matrixes will lead to a third matrix, which can be involved in operations with two first ones, etc. It is known that matrix algebra is well-developed branch of mathematics. Opportunities of the matrixes allow describing diverse physical processes using numerical actions over the elements of these matrixes. This, in turn, will make it possible to obtain a set of specific numerical data, which can be further used. Next, they can be applied for creation of the corresponding matrixes, which can be processed independently upon solutions of specific objectives.

The material discussed in the present paper is a logical framework based on theoretical representations (in particular, of quantum physics). In our opinion, this represents a first and necessary step (together with the ideas stated in the manuscript [5]) which allows to create, at least, an experimental sample of the device which then can help to solve the problem of quantum computation performance on a wide scale.

3 Conclusion

The real Shor's states are quantum-physical in essence. Therefore, the massif of quantum islets used for their visualization should retain this physical feature, i.e. obey to the laws of quantum physics. It is obvious that today among classical representatives of such objects are heterosystems with reduced dimension or low-dimensional structures, in which the motion is limited in one, two or three direc-tions. Quantum limitation is realized when the characteristic quantum length, defined by de Broglie wavelength, becomes equal or lower than the corresponding physical size of object. This condition should be somehow realized in structure and composition of quantum islets, which should play the role of q-bits. From technological point of view, manifestation of size quantum effects should be un-derstood as a need for providing of such conditions in the course of a materialization of the Shor's states, when the size (sizes) of individual quantum inlet and some critical length characterizing struc-ture and (or) properties of this islet should coincide. Understanding of this fact should lead to active participation of quantum islets in the organization of calculation procedure.

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