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Some Systems of Quantum Computing

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Abstract

We have searched for systems that can be realized after the introduction of the concept of computer design using the laws of quantum mechanics. In this work, quantum electrodynamics, fullerenes, molecular magnets, NMR and EPR spectroscopy, biradikals, light polarization and superconducting devices have been mentioned in quantum computers. Quantum electrodynamics, fullerenes, molecular magnets, NMR and EPR spectroscopy, Light polarization and superconductors are mentioned in quantum computers. These systems have been tried to be shown separately. As a result, the fullerenes from the systems in which the quantum computer can be realized are mainly in the systems in which quantum computation can be carried out, in particular with magnetic resonance spectroscopy, for a number of reasons such as being stable, being able to place atoms in the fullerenes. Another system is superconductors, which can be realized if the temperature is high. It is thought that light polarization can be a powerful system in which the polarizable light can be processed by quantum computing. EPR, NMR spectroscopy, quantum electrodynamics, molecular magnets and biradikals, where quantum computation can be performed, are promising as physical structures.

Keywords: *Quantum computing, fullerenes, quantum elektrodynamics, superconductors, biradikals.*

Kuantum Bilgisayarlarının Gerçekleştirildiği Sistemler

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Özet

Bilgisayar tasarımı kavramının kuantum mekaniği yasalarını kullanarak tanıtılmasından sonra gerçekleşebilecek sistemleri araştırdık. Bu çalışmada kuantum bilgisayarlarda kuantum elektrodinamik, fullerenler, moleküler mıknatıslar, NMR ve EPR spektroskopisi, biradikaller, ışık polarizasyonu ve süper iletken cihazlar anlatılmıştır. Kuantum elektrodinamiği, fullerenler, moleküler mıknatıslar, NMR ve EPR spektroskopisi, Işık polarizasyonu ve süper iletkenlerden bahsedildi. Bu sistemler ayrı olarak gösterilmeye çalışılmıştır. Sonuç olarak, kuantum bilgisayarın gerçekleştirilebildiği sistemlerdeki fullerenler kararlı olma, fullerenlere atom yerleştirilmesi gibi özelliklerden dolayı kuantum hesaplamanın, özellikle manyetik rezonans spektroskopisi ile gerçekleştirilebildiği güçlü sistemlerden biridir. Bir diğer sistem, süperiletkenler olup, yüksek sıcaklıkta bulunduğunda gerçekleşebilir. Işık polarizasyonu, kutuplaştınlabilir ışığın kuantum hesaplamayla işlenebileceği güçlü bir sistem olabileceği düşünülmektedir. EPR, NMR spektroskopisi, kuantum elektrodinamiği, moleküler mıknatıslar ve kuantum hesaplamanın gerçekleştirilebileceği biradikaller fiziksel yapılar olarak umut vericidir.

Anahtar Kelimeler : Kutrit, kübit, hadamart geçidi, swap geçidi, kuantum hesaplama.

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1. Introduction

The concept of quantum computer design has emerged. In this work, it is aimed to examine some physical systems and techniques that quantum computers can realize. These are quantum electrodynamics, fullerenes, molecular magnets, Biradikaller, nuclear magnetic resonance (NMR) spectroscopy, electron paramagnetic resonance (EPR) spectroscopy, superconducting devices and light polarization. It has been researched under which conditions these systems can be used in practice. In quantum computer design, fullerenes, superconductors and light have been found to come to the forefront with features they possess. It is possible to realize this application when the light can be polarized, superconductors in high temperature, systems where spin can be controlled.

2. Materials and Methods

It was first suggested by Richard Feynman in 1986, using the laws of quantum mechanics to design computers[1]. Feynman predicted that using a classical computer a simulation of a quantum system would require quite a long time and stated that there must be a system that can solve the problems that are difficult or impossible to solve in the year [1].

Peter Shor has shown that quantum computers can be used to solve a mathematically difficult problem [2]. For example, to divide a 250-digit number into prime multipliers, assuming that the publication is based on the year of publication, even hundreds of parallel-connected classical computers are estimated to take a hundred million years, while quantum computers are expected to account for these calculations for minutes.

But like all physical systems, quantum mechanical systems are also interacting with their environment, and this interaction can lead to errors due to the influence of the environment in computing. It is therefore an interaction that weakens the superiority of quantum computers. Peter Shor and Adrew Steane, who saw this drawback, showed that qubic error correction is possible [3]. For example, the single qubit $c_1|\beta\rangle + c_2|\alpha\rangle$ can be transformed into an error $c_1|\alpha\rangle + c_2|\beta\rangle$ into an error. In order to prevent this situation, this system should be reversible without distorting the system, ie without changing the α and β coefficients. In this system, $c_1|\beta\rangle + c_2|\alpha\rangle$ can be coded as $c_1|\beta\beta\beta\rangle + c_2|\alpha\alpha\alpha\rangle$ using two auxiliary qubes. Thus, the information in a single bit is encoded in three bits at a fuzzy level. Taking the reverse of these operations, additional bits can be measured to determine if there is an error. With the help of this information, it is possible to carry out the correct operations with error correction processes performed at certain stages.

There are certain physical systems and techniques in quantum computers that can perform all of these processing steps. There are many suggestions about these systems and techniques. Some of these systems and techniques are outlined below[3,4].

3. Results and Discussion

3.1. Quantum Electrodynamics

Quantum electrodynamics has emerged in the 1940s as a theory that combines quantum mechanics and special relativity on the interaction between quantum mechanics and electromagnetic theory and the interaction between light and matter.Quantum electrodynamics identified Richard Feynman as 'the jewel of physics' [5]. Because it predicted the Lamb slip in the energy levels of the hydrogen atom and the electron accurately predicted the abnormal magnetic moment. Feynman mentions three fundamental movements in quantum electrodynamics.

1. A photon can go from place to place and time to time.
2. An electron can go from one place to another and time to time.
3. An electron emits a photon at a specific location and time or cools it.

In all three movements there are two cases, that is, when each motion is taken separately, it brings

A qubit system to the square and thus forms a suitable system if it can be controlled to perform quantum computation.

3.2. Fullerenes

Specific molecular structures known as fullerenes or buckminster fullerenes can be defined as molecules of a kind entirely composed of carbon atoms. It can be found in cylinders, spheres or ellipsoidal shapes. The smallest known member of the fullerenes is C_{20}, the most common being the C_{60} and C_{70} molecules. Cylinders or oval ones are known as carbon nanotubes, and the number of carbon atoms is naturally very large in these structures. C_{60} from these structures, which are about 1 nm in size; 20 hexagons, 12 pentagons and 60 carbon atoms.

Fullerenes have a unique inner space due to extraordinary cage constructions. The dimensions of the inner space allow some atoms and small molecules to be placed inside the fullerenes. The structures formed by putting an atom or group of atoms into it are called endohedral fullerenes. With different techniques, fullerenes can contain atoms or small groups of atoms. These constructions are shown in the form of $M@C_{60}$is used as a substitute for metal, and ametals can be placed. The resulting structure may be a nitrogen atom such as $N@C_{60}$ or an atom from the group of lanthanides such as $La@C_{60}$ For many reasons, such as being stable, being able to place atoms in the fullerenes, the fullerenes are at the beginning of physical structures in which quantum computation can be performed, especially with magnetic resonance spectroscopy [6].

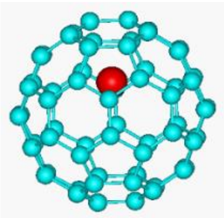

Figure 2. Structure of an endohedral fullerene (Represents an atom placed in a red round cage)

3.3. Moleculer Magnets

Molecular magnets or organometallic complex structures consist of a single molecule that is magnetized under a certain critical temperature. In these structures, Mn^{+2} or Fe^{+3} is usually present as the metal. The magnetic dipole moments of the molecular magnets indicate that these magnets can be examined by magnetic resonance spectroscopy or their behavior can be controlled. Thus, such structures are promising as the physical structure.

3.4. Biradicals

Biradicals or radical pairs are molecules with two unpaired electrons. The distance between these two electrons, which match each other, is of molecular or atomic size. The atom or group to which the two electrons that make up the biradical are connected is usually identical, but may be rarely different.

In the crystal of $K_2S_2O_8$ or $(NH_4)_2S_2O_8$ exposed to high energy radiation, there is a very stable structure of $SO_4^- - SO_4^-$ ionic bidentate bound to two SO_4^- group with zero spin and has a very stable structure for EPR spectroscopy. It is a simple structure [7]. The dinitroxide radicals in the form of $\dot{N}O - \dot{N}O$, which are formed by the bonding of two of the stable radicals nitroxide radicals, are other commonly known stable radicals. In addition to biradicals, triradicals are some of the other interesting behaviors observed.

3.5. Nuclear Magnetic Resonance (NMR) Spectroscopy

Nuclear magnetic resonance spectroscopy is widely used due to the fact that pulse and Fourier transform techniques are common and easy to perform in the realization of quantum information theory[3,8]. The spin-spin and core quadrupole moment interactions, predominantly chemical shifts are commonly used in quantum computation when the molecules are structurally determined by NMR technique.

3.6. Electron Paramagnetic Resonance (EPR) Spectroscopy

In electron paramagnetic resonance (EPR) spectroscopy, all nuclei containing unpaired electrons and interacting with unpaired electrons can be examined with a single nucleus without the need for additional equipment. This feature is characteristic of EPR spectroscopy. Paramagnetic structures suitable for quantum computing must first be stable. Stable constructions providing this condition can be given as some molecules, transition metal ion complexes, complexes made with lanthanides, trapped ions, endohedral fullerenes, and nanotubes and molecular magnets[9].

3.7. Superconducting Devices

Superconductors are defined as materials that transmit electricity without any resistance. A superconducting dipole (a current loop) continues uninterrupted without external intervention after the current has been initiated. The direction of the magnetic dipole moment in such a superconducting current loop can be made up or down (represented by a qubic system) depending on demand, so long as it is maintained, it is stable, so long as it is not desired. In quantum computing, these dipoles will be in nanometric dimensions.

Currently available superconductors are formed at 4 K temperature. If superconductors at high temperature (high T_c superconductors) are found, it is possible to realize this application [4].

3.8. Light Polarization

Electromagnetic waves, light is an electromagnetic wave, consisting of alternating electric and magnetic field components perpendicular to the direction of propagation and perpendicular to each other, so the light is polarized. However, the light emitted from a source will oscillate in all directions in the plane perpendicular to the direction of propagation when no application is made. If a polarizer is used, a beam can only be polarized in the direction of the polarizer. By utilizing this feature, the light can be polarized in the desired direction.

For example, if the light emitted in the z direction can be polarized in the x and y directions, optionally with a polarizer, this bipolar state will form a qubit. This indicates that the polarizable light will be a strong physical candidate for quantum computing.

Fullerenes from systems that quantum computers can perform are especially important in systems where quantum computation can be performed, especially with magnetic resonance spectroscopy, for many reasons, such as being stable, being able to place atoms in the fullerene. Another system is superconductors, which can be realized if the temperature is high. It is thought that light polarization can be a powerful system in which the polarizable light can be processed by quantum computing. EPR, NMR spectroscopy, quantum electrodynamics, molecular magnets, and amendments, where quantum computation can be performed, are promising as physical structures.

4. Conclusions

Physical systems and techniques were sought after the introduction of the concept of computer design using the laws of quantum mechanics. In this work, quantum electrodynamics, fullerenes, molecular magnets, singularities, NMR and EPR spectroscopy, light polarization, and superconducting devices have been mentioned in quantum computers. These systems have been tried to be shown separately. It has been demonstrated that each of these systems can be used in a quantum computer design under separate conditions.

In this study, quantum electrodynamics, fullerenes, molecular magnets, single crystals, NMR and EPR spectroscopy, light polarization and superconductors were investigated separately and the feasibility in application was investigated in quantum computers. Light polarization, fullerenes, and superconductors have come to the fore in quantum computer design.

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