ANALYSIS OF BASIC SCIENCES IN COMPUTERS AND QUANTUM TECHNOLOGY

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Abstract – *Quantum computers are machines that are characterized by having power and speed, physical characteristics that can be used to optimize research that requires the management of a large amount of data and information, such as: solving many open problems in science, searching for a cure. to diseases, discover new organic materials, help improve the environment and social problems, etc. In these times where the technological revolution allows researchers from different parts of the world to work on the development of new quantum technologies, based on quantum mechanics or atomic nature due to the particles that make up the atom, they are very complex and very expensive laboratory technologies that They are developed experimentally by large companies with limited success. However, engineers and physicists predict that in the medium term we will begin to feel the social impact of new quantum technologies due to their multiple applications in different areas of science such as mathematics, cryptography, construction of materials, communications, commerce, finance, education, genetics, medicine, transportation, meteorology and among others.*

Keywords: *quantum computers, qubits, quantum logic, quantum technology, atomic stability.*

INTRODUCTION

This paper describes the development of quantum computing and its advances, as well as the solution of many questions about this technology such as: what is a quantum computer?, will quantum computers replace classical computers?, why has Google come to turn off its quantum computer and what technology has it created exactly?, How long ago did research in quantum computing begin?, What is the mathematical logical basis of quantum computing?, What capacity should a quantum computer have?, How should quantum programs be designed to obtain correct answers?, What is the best system for quantum or conventional computing?, What quantum processors exist?, What are the platforms or programming languages that allow quantum applications?, Which company or companies have made the most progress in quantum computers?, What applications or software are designed with quantum systems?, What flaws do quantum computers have?, In which companies or institutions are quantum devices developed or used?, In what areas of science can the advances obtained in quantum computers be applied?, What projects or expectations do companies that use or manufacture quantum technology have?, What is the fear of using or producing quantum technology?, How will they overcome the challenge of obtaining a stable quantum technology?

1. METHODOLOGY

This is research with a qualitative research approach because it seeks to understand the phenomena or situations about quantum mechanics and its applications to computers, which are one of the contexts where this scientific knowledge is being applied. According to Kemmis, this paradigm is characterized by being based on experience, intuition, the evaluation of processes, on relating facts that allow a better study, closely relating the researcher with the researched and finally making descriptions based on observations in a real context.

Within this qualitative approach, the research was designed in a cross-sectional and descriptive way. According to Hernandez, Fernandez, and Baptista [1], descriptive research is characterized by presenting the information as it is, indicating what the situation is at the time of the research, analyzing, interpreting, printing, and evaluating what was achieved from the entire research process.

The instruments used to collect the information in this research are the following: 1. Research on quantum computers.

2. Questionnaire with open and closed questions to learn about the history, development and advances in quantum computing and its applications.
3. Experiences of the scientific community on the use of quantum mechanics in computers.
4. Reports on the progress and designs of institutions or companies that use or design quantum computers.
5. Reflections on quantum computers in the workplace.

2. Quantum mechanics and computers

It has always been the case that technology progresses rapidly; Lately, however, the advancement of technology has been significantly extraordinary. Well, we talk about quantum computing, and we ask ourselves questions like: **What is a quantum computer?** According to [2], a quantum computer is a type of computer that uses quantum mechanics to perform certain types of calculations more efficiently than a normal computer. Unlike classical computers, which use bits to process information, quantum computers use qubits, which are subatomic particles such as electrons or photons. Qubits can have both processing states at the same time, which makes them tremendously difficult to predict and everything will be based on approximations to one state or the other. Quantum computers take advantage of some of the almost "mystical" phenomena of quantum mechanics to offer great advances in processing power (the premise is that a simple quantum computer would be more powerful than today's supercomputers).
Will quantum computers replace classical computers? It is important to note that quantum computers will never be able to replace the PCs we use today, at least not for a considerable time or a medium period. The use of a home or "normal" PC is still one of the most economical solutions to solve the everyday problems and needs of users, and this will remain the case for a long time [3]. However, quantum computers promise to drive technological advances in many fields, from materials science to pharmaceutical research, which is why many companies are investing in this technology.
And even people who are at the forefront of advancement are afraid, like Google, which has recently shut down its quantum computer because of something scary that's happening**, why has Google come to this decision?** and **What technology have you created exactly?** Quantum computing is one of the hottest topics today, it is an emerging technology that takes advantage of the laws of quantum mechanics to solve problems too complex for classical computers, this new technology uses the principles of quantum mechanics, which describes the behavior of matter and energy at the smallest scales in which particles such as electrons and photons can exist in superposition with the quantum mechanics. a combination of two or more states as well as entanglement or correlation between two or more particles [4].
But **how long ago did research into quantum computing begin?** The foundations of quantum computing today were laid in the 1920s by Albert Einstein, Niels Bohr, Planck, Werner Heisenberg, Louis-Victor de Broglie and others, and were discussed at the Fifth Solvay Congress in 1927 by the most distinguished scientists of the time. In the 1980s, when Paul Benioff, Richard Feynman and Yuri Manin proposed the idea of using quantum systems to perform calculations [5]. One of the first quantum computer models was developed by David Deutsch in 1985, who showed that a universal quantum computer could simulate any physical process. Quantum computing uses these phenomena to encode and manipulate information into quantum bits or qubits, which are the basic units of quantum information. They realized that quantum computers could exploit the parallelism and interference of quantum states to solve certain problems more quickly than classical computers. Since then, considerable progress has been made in this field. This is how IBM introduced the first commercially available quantum computer in 2016. While Google claimed to have achieved quantum supremacy in October 2019 with its Sycamore computer [6].
What is the mathematical logic foundation of quantum computing? Quantum computing works by applying quantum logic gates to qubits, which are typically implemented using physical systems such as superconducting circuits, trapped ions, photons, or atoms. Quantum logic gates are operations that change the state of one or more qubits according to certain rules, for example, a Not gate changes the state of a qubit from zero to one or vice versa while a CNOT gate changes the state of a second qubit only if the first qubit is one. By combining several quantum logic gates, quantum algorithms can be created that perform specific tasks on qubits.
Quantum computing differs from classical computing in several ways, firstly, quantum computing uses qubits instead of bits that can store more information than a zero or a one. Mathematically, a qubit is described as a qubit. Unit Module Vector in a Vector Spacecomplextwo-dimensional [7]. The two basic states of a qubit are and , which correspond to 0 and 1 of the classical bits (pronounced:$|0\rangle|1\rangle$ Ket zero and ketone). In addition, the qubit may be in a state of Quantum Superposition or a combination of those

two states. In this it is significantly different from the state of a$(\alpha|0\rangle + \beta|1\rangle)$ bit classic, which can only take values 0 or 1.

Representation of a qubit in the ground state is: $|0\rangle = \begin{pmatrix}1\\0\end{pmatrix}$ and $|1\rangle = \begin{pmatrix}0\\1\end{pmatrix}$

Representation of a qubit in a state of superposition: $|\psi\rangle = \alpha|0\rangle + \beta|1\rangle = \begin{pmatrix}\alpha\\\beta\end{pmatrix}$ with .$\|\alpha\|^2 + \|\beta\|^2 = 1$

A qubit can be in any superposition of zero and one which means that it can have a certain probability of being in either of the two states, for example, a qubit can be in a state of 0.6 + 0.8 where and represent the base states of zero and one respectively; this means that the qubits have a 36% chance of being measured as zero and a 64% chance of being measured as zero. 1, because the total probability has to be unity, i.e., $|0\rangle|1\rangle\alpha|0\rangle\beta|1\rangle\|\alpha\|^2 + \|\beta\|^2 = 1$where and represent the probability that the qubit has in the respective state$\|\alpha\|^2\|\beta\|^2$; whereas a classical bit can only store one value at a time. Second, quantum computing uses entanglement to create correlations between qubits, which can increase the computing power of quantum algorithms. Entanglement is a phenomenon in which two or more clubs share a quantum state and behave as a single system, even though they are physically separated, this means that if one qubit is measured as zero the other qubits will also be zero with certainty and vice versa, entanglement allows quantum algorithms to manipulate several cubes at once and exploit their correlations to achieve a speed higher than that of classical algorithms. Third, quantum computing uses interference to amplify desired outcomes and suppress undesired ones. Interference is a phenomenon in which two or more romantic states combine to form a new state based on their relative phases, e.g., states with the same phase will add up constructively; while two states with opposite phases will destructively cancel each other out.

A Quantum Logic Gate is a basic quantum circuit that operates on a small number of qubits. These gates are represented by unit arrays that act on the probability amplitudes of the qubits. But primitive gates, or those that are called universals, see IBM QX Quantum Experience Editor, are 2×2 arrays that meet all the conditions specified above. The most used quantum logic gates are:[8]

- **Pauli matrices: X, Y, Z.**
  - **The quantum gate X,** analogous to NOT

$$X = \begin{pmatrix}0 & 1\\1 & 0\end{pmatrix}\begin{pmatrix}\alpha\\\beta\end{pmatrix} = \begin{pmatrix}\beta\\\alpha\end{pmatrix}$$

  - **The quantum gate Y**, since its action is on a qubit is the Y transformation, travels along the interval in the Bloch sphere on the surface of the sphere from $|0\rangle$ to $|1\rangle$, rotating values around the y-axis.

$$Y|0\rangle = \begin{pmatrix}0 & -i\\i & 0\end{pmatrix}\begin{pmatrix}1\\0\end{pmatrix} = \begin{pmatrix}0\\-i\end{pmatrix}$$
$$Y|1\rangle = \begin{pmatrix}0 & -i\\i & 0\end{pmatrix}\begin{pmatrix}0\\1\end{pmatrix} = \begin{pmatrix}-i\\0\end{pmatrix}$$

  - **Quantum gate Z**, is defined by the matrix (unitary)

$$Z = \begin{pmatrix}1 & 0\\0 & -1\end{pmatrix}$$

Its action is:

$$|0\rangle \to Z \to |0\rangle$$
$$|1\rangle \to Z \to -|1\rangle$$

The linear transformation Z changes the sign of the amplitude when applied to the state of the qubit $|1\rangle$ and leaves it the same when operating with the state of the qubit $|0\rangle$.

Other important quantum gates, among these are:

- **The H gate or Hadamard gate:** defined by the (unitary) matrix:

$$H = \frac{1}{\sqrt{2}}\begin{pmatrix}1 & 1\\1 & -1\end{pmatrix}$$

Its action is:

$$|0\rangle \to H \to \frac{1}{\sqrt{2}}(|0\rangle + 1\rangle)$$
$$|1\rangle \to H \to \frac{1}{\sqrt{2}}(|0\rangle - |1\rangle)$$

The Hadamard gate is widely used in quantum computing algorithms because it allows the management of the evolution of states in superposition, until reaching a place where measuring that superposition is useful to contribute to solving the problem with the algorithm in question.

- **CNOT (Control Not) Quantum Gate**: This is an uncontrolled gate. Controlled gates operate on 2 qubits or more. In this case, its effect is:

$$|xy\rangle \rightarrow CNOT \rightarrow |x\ \ x \oplus y\rangle \text{ with } x, y \in \{0,1\}$$

$xyx = 1y$The first qubit is called control. Control is invariant in transformation. The second qubit is called the target. The goal is denied when . That is, it doesn't change if $x = 0$.

- **Toffoli Gate.** The Toffoli gate covers the need to have a minimum of three qubits. The three-qubit extension of the CNOT gate is denoted as CCNOT or Toffoli gate (In the IBM Composer, the object is called CX). To do this, two control bits are defined that only act if they are at 1. Applying it twice results in identity. Therefore, it is a reversible door (its inverse is itself). The matrix expression is:

$$U_T = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{pmatrix}$$

The classical Toffoli gate is a transformation of 3-qubits that changes the third qubit, when the first two are 1. Obviously, it is a unitary transformation.

3. Analysis and discussion of results

What capacity should a quantum computer have? To answer this question let's consider the following situation, if you take a system of electrons in which electrons can be in any of the 40 positions. It would imply that electrons can be in either 2^40 configuration because each position may or may not have an electron. To store the quantum state of electrons in the memory of a conventional computer, more than 130 GB of memory is needed. If you allow the particles to be in any of the 41 positions, you will have twice as many configurations in 2^41, which would require more than 260 GB of memory to store the quantum state. This game of increasing the number of positions cannot be played indefinitely if you want to store the state conventionally, because it would quickly outgrow the memory capacities of today's machines. With a few hundred electrons, the memory needed to store the system exceeds the number of particles in the universe; Therefore, it is not impossible for our conventional equipment to simulate its quantum dynamics [5]. And yet, in nature, these systems easily evolve over time according to the laws of quantum mechanics, completely unaware of their inability to design and simulate their evolution with the power of conventional computing.

How should quantum programs be designed to get the right answers? Quantum algorithms use interference to increase the probability of measuring the correct answer and decrease the probability of measuring the wrong answer This requires careful design of quantum logic gates and their sequences to create patterns of constructive and destructive interference Quantum computing is better than classical computing for some problems involving large amounts of data, complex calculations, or optimization, for example, computers Quantum scientists can factor large numbers faster than classical ones using Shor's algorithm, which has implications for breaking RSA or DF Hellman-based encryption schemes. Quantum computers can also search large databases faster than classical computers using Grover's algorithm, which has implications for data mining or machine learning, quantum computers can also simulate quantum systems more efficiently than classical computers using various methods such as eigen solver, variational quantum or quantum phase estimation, which has applications for chemistry, physics, and biology.

Which system is better, quantum computing or conventional computing? To answer this question, we will present some cases where quantum computing is better than normal computing:

- factoring large numbers, one of the most famous applications of quantum computing is Shor's algorithm, which can factor a large number into its prime factors in polynomial time; While the best classical algorithms take exponential time, this has implications for cryptography as many encryption schemes rely on the difficulty of factoring large numbers [9].
- Searching unsorted databases, another well-known quantum algorithm is Grover's algorithm, which can search an unordered database of n elements in time or square root n; While the best classical algorithm takes an n-times, this can be useful for finding the proverbial needle in a haystack or a matching record in a large database [10].
- Simulation of quantum systems, quantum computers can naturally simulate other quantum systems such as molecules, atoms, or particles; While classical computers struggle to model the complex interactions and dynamics of quantum systems, this may enable advances in chemistry, physics, biology and materials science, as well as the design of new drugs and materials [11] [12].
- Optimizing combinatorial problems, quantum computers can also tackle difficult optimization problems, such as the traveling salesman problem or the backpack problem, which involve finding the best solution among many possible solutions. Quantum computers can use techniques such as annealing or approximate quantum optimization algorithms to find near-optimal solutions in less time than classical computers. Machine learning and artificial intelligence, quantum computers can also enhance machine learning and artificial intelligence applications such as classification, clustering, regression, or reinforcement learning.
- Quantum computers can take advantage of quantum data structures, such as qubits or quantum neural networks, to store and process more information than bits or classical neurons.
- Quantum computers can also use quantum algorithms, such as support vector quantum machines or quantum principal component analysis to perform faster and more accurate calculations than classical algorithms.

What quantum processors are there? Google's quantum processors are one of the most advanced and promising technologies in the field of quantum computing, they use superconducting circuits to create and manipulate qubits, the basic units of quantum information, superconducting qubits, have several advantages over other types of qubits, such as high coherence times, fast gate operations, and scalability. One of the challenges of quantum computing is to design and apply algorithms that can take advantage of the quantum properties of qubits such as superposition and entanglement.

What are the platforms or programming languages that allow quantum applications? To meet this challenge, Google has developed a framework called Cirq, which allows users to program and simulate quantum circuits on Google's quantum processors, Cirq is an open-source Python library that offers a simple and intuitive interface for creating and manipulating quantum circuits, Cirq is also compatible with various quantum hardware platforms such as Google's Sycamore processor, that achieved quantum supremacy in 2019, performing a task that would be impossible for a classical computer. Cirq allows users to explore various aspects of quantum computing such as error correction, noise mitigation, optimization, and benchmarking [13].

Cirq also integrates other tools and frameworks such as Tensorflow Quantum, which allows users to apply machine learning techniques to quantum data, such as Tensorflow Quantum, which allows users to apply machine learning techniques to quantum data. optimization, artificial intelligence, and quantum chemistry. Using superconducting technology and providing an accessible and flexible framework, Google is making quantum computing more feasible and accessible to researchers and developers around the world. Another notable achievement of Google's quantum computing came in 2019, when Google's Sycamore, performing in 200 seconds a calculation that a classical supercomputer would take 10,000 years to complete, was a demonstration of quantum supremacy, the point at which a quantum computer can outperform any classical computer at a specific task [14].

Which company or company has made the most progress in quantum computers? Quantum supremacy is a milestone for quantum computing, a field that promises to revolutionize many areas of science and technology, **how did Sycamore achieve this?** It used 53 qubits, the basic units of quantum information, to generate a random sequence of bits that follows a certain distribution, this task is easy for a quantum computer because cubes can exist in a superposition of two states 0 and 1 at the same time, this means that cubes can explore multiple possibilities simultaneously, Which gives them an exponential advantage over classical bits that can only be 0 or 1 and this specific task would be extremely difficult for a classical computer because it would have to simulate all the possible states of qubits and their quantum interactions that grow exponentially with the number of qubits.

The world's best supercomputer, Summit, would need 10 years to perform this simulation according to Google's estimates, but Sycamore did it in just over 3 minutes with great accuracy and fidelity. This achievement was hailed as a breakthrough for quantum computing; But it also sparked controversy among some experts: IBM, one of Google's competitors in quantum computing, questioned Google's claim of quantum supremacy. IBM argued that Summit could perform the same task in 2 1/2 days with an improved algorithm and more memory. IBM also questioned Google's definition of quantum supremacy, stating that quantum computers will never reign supreme over classical computers, but will work in concert with them.

Google, however, defended its claim of quantum supremacy by saying that its calculation was not only faster but also more complex and realistic than IBM's proposed simulation. Google also said that quantum supremacy is not about comparing quantum and classical computers on arbitrary tasks, but about demonstrating that quantum computers can do things that are beyond the reach of classical computers. The debate over quantum supremacy is not yet settled; But it shows how much progress has been made in quantum computing and how much more has yet to come. Quantum computers have the potential to solve problems that are insoluble for classical computers, such as finding new drugs, optimizing logistics, breaking encryption, and advancing artificial intelligence.

Google's quantum supremacy experiment is presented as a glimpse of the future. Another software tool that Google provides is Tensorflow Quantum, an open-source library for hybrid quantum classical machine learning. Tensorflow Quantum integrates Cirq with Tensorflow, the popular machine learning framework. And it allows users to build quantum data pipelines and quantum neural networks. For quantum chemistry applications, Google has developed OpenFermion, an open-source library that allows you to compile and analyze quantum algorithms, to simulate thermionic systems such as molecules and materials, OpenFermion, can interact with Cirq and Tensorflow Quantum, to apply various quantum chemistry methods such as eigen solves, quantum variations, and quantum phase estimation.

What applications or software are designed with quantum systems? Google's software tools are designed to work with Google's hardware platforms, which are among the most advanced quantum processors in the world. Google's latest quantum processor, Sycamore, has 54 superconducting qubits and can perform high-fidelity and low-crosstalk operations. Sycamores, was used to demonstrate quantum supremacy as already mentioned in 2019 by performing a calculation that would be impracticable with classical computers. Google is also working on developing new hardware architectures and techniques to improve the performance and scalability of quantum processors, for example, Google is exploring topological quantum states that are robust to local errors and can enable fault-tolerant quantum computing.

What are the flaws of quantum computers? Google is also researching quantum error correction schemes such as repeat codes and surface codes to protect logical qubits from noise and decoherence. Google's research on quantum computing takes place at the AIK campus in Santa Barbara, California, which houses a state-of-the-art quantum data center, manufacturing facilities, research labs, and workspaces. The campus is home to a team of world-class researchers and engineers who collaborate with partners from academia and industry to advance the field of quantum computing.

Google's vision is to build the world's first fault-tolerant quantum computer and develop novel quantum algorithms that help solve short-term applications for practical problems. By offering software tools and libraries for quantum machine learning and quantum chemistry, Google aims to empower researchers and developers to explore the possibilities of quantum computing and discover what lies beyond classical computing. Google continues to make giant strides in quantum computing and artificial intelligence, the tech giant has announced that it will build a quantum AI Campus in Santa Barbara California, which will house a quantum data center, a manufacturing facility, research lab, and a workspace for its quantum team, the campus will be the headquarters of Google's quantum artificial intelligence division, led by John Martinez, a former professor at the University of California, Santa Barbara, and one of the world's leading experts on quantum computing.

In which companies or institutions are quantum devices developed or used? The quantum data center will house Google's quantum processors, which are devices that use the principles of quantum mechanics to perform calculations that are impossible or impractical for classical computers. The quantum data center will allow Google to expand its quantum computing capabilities and run more complex and powerful algorithms. The manufacturing center will be where Google will design and manufacture its quantum processors and other components, giving Google more control and flexibility over its quantum hardware and allowing it to experiment with different architectures and materials. Google will also collaborate with external partners and researchers to share its manufacturing knowledge and resources. The research lab will be the place where Google will conduct cutting-edge research in quantum computing and artificial intelligence.

Google enjoys a strong reputation in both fields and has published numerous influential papers and breakthroughs, the research lab will foster innovation and collaboration among Google's quantum scientists and engineers, as well as with academic institutions and other organizations. Some of the topics Google will explore are quantum error correction, quantum machine learning, quantum optimization, quantum chemistry, and cryptography. The workspace will be the place where Google's quantum team will work and interact with each other, the workspace will be designed to create a stimulating and inspiring environment for the quantum team, which is made up of more than 100 people from diverse backgrounds and disciplines.

The workspace will also host quantum community events and workshops, such as hackathons, seminars, and training sessions. Google's quantum AI campus in Santa Barbara will be completed in 2024, it will be a major milestone for Google and for the field of quantum computing and artificial intelligence. Google hopes that the construction of this campus will accelerate the development of quantum technologies and applications that can benefit humanity and society. One of the main applications of quantum computing for AI is machine learning, which is the process of learning from data and making predictions or decisions based on it. Machine learning algorithms typically rely on linear algebra operations such as matrix multiplication and inversion that can be accelerated by quantum computers. Google has developed several quantum machine learning algorithms, such as quantum neural networks, support vector machines, and quantum principal component analysis that can harness the power of hands-on computers to learn from large, complex data sets.

In which fields or areas can the advances made in quantum computers be applied today? Another application of quantum computing to AI is NLP, the branch of AI that deals with understanding and generating natural language. NLP tasks include speech recognition, machine translation, sentiment analysis, and text summarization. Google has been studying how quantum computers can help in NLP tasks, for example, by using quantum annealing to find optimal solutions for word embedding, which are numerical representations of words that capture their meanings and relationships. Google has also proposed a quantum algorithm for text generation, which can produce coherent and diverse texts from a given prompt.

Another application of quantum computing to AI is also being studied, such as computer vision, the branch of AI that deals with analyzing and interpreting visual information. Computer vision tasks include facial recognition, object detection, scene segmentation, and image synthesis. Google has been experimenting with how quantum computers can improve computer vision tasks, for example by using quantum convolutional neural networks, to perform image classification, which can recognize which objects are present in an image. Google has also demonstrated a quantum imaging algorithm capable of creating realistic and novel images from a given input.

What projects or expectations do companies that use, or manufacture quantum technology have? Google's vision is to create a scalable and universal quantum computer that can tackle any problem that is beyond the reach of classical computers, by applying quantum computing to AI, Google hopes to unlock new possibilities and discoveries in fields such as science, medicine, engineering, and art [15]. Google believes that quantum computing and AI can work together to create a positive impact on humanity and society; However, quantum computing also faces a major challenge: that of coherence, coherence is the loss of quantum coherence, the process in which the behavior of a system changes from what can be explained by quantum mechanics to what can be explained by classical mechanics. Decoherence occurs when a quantum system interacts with its environment such as noise, heat, or electromagnetic fields and becomes entangled with it, causing the quantum system to lose its superposition of states, a key feature that allows quantum computers to perform parallel calculations and reach exponential speeds higher than those of classical computers. Decoherence is a serious problem for quantum computing because it limits the time and accuracy of quantum operations and algorithms.

What is the fear of using or producing quantum technology? If decoherence occurs too quickly or intensively, the quantum computer will lose its advantage over classical computers and produce erroneous results, therefore, it is crucial to find ways to protect quantum systems from coherence and extend their coherence times, for these various techniques can be used such as: error correction codes, fault-tolerant architectures, dynamic decoupling methods, and optimal control strategies. Google is currently working on various aspects of coherence control in quantum systems, both theoretically and experimentally, for example, Google's quantum processor called Sycamore, uses superconducting qubits, which are artificial atoms capable of storing and manipulating quantum information. Sycamore has achieved a coherence time of about 10 microseconds for each qubit, enough to perform thousands of quantum operations before decoherence occurs.

Google has also demonstrated quantum supremacy with Sycamore which means that it performed a task that would be impossible for a classical computer in a reasonable amount of time, this task consisted of generating random numbers, using a quantum circuit with 53 qubits and verifying its statistical properties. Another example of Google's work in controlling coherence is its collaboration with researchers at Stanford and Santa Barbara universities to develop a new type of qubit called qubits not a nome qubits, a variation of a superconducting qubit that has an adjustable coupling strength with its neighbors. This means hobbits can be turned on and off as needed, reducing unwanted interactions with the environment and increasing consistency time. The researchers have shown that nome qubits can achieve coherence times of up to 75 microseconds and perform with high-fidelity 2-qubit gates.

Google's research on coherence control in quantum systems is not only important for the advancement of quantum computing but also for understanding fundamental aspects of quantum physics. Decoherence is often considered a bridge between the quantum and classical worlds, studying how it affects different types of systems can reveal new insights into the nature of reality, for example, Google has used Sycamore, to test whether quantum mechanics is valid on a large scale, observing how entanglement decays as the size of the system increases. Google has also used nome qubits to explore how decoherence affects quantum phase transitions, which are sudden changes in a system's behavior when a parameter is varied.

Google's work on coherence control in quantum systems demonstrates that decoherence is not only a challenge but also an opportunity for innovation and discovery. By developing new ways to protect and manipulate quantum information, Google is pushing the boundaries of what's possible with quantum technology and opening up new horizons for science and society; However, Google has shocked the world by announcing the closure of its quantum computer project, the company that was one of the pioneers of quantum computing, has stated that it has reached a fundamental limit in its ability to reduce errors and scale its qubits [16].

What is the challenge to overcome to obtain a stable quantum technology? One of the main challenges of quantum computing is maintaining the coherence of qubits, the basic units of quantum information, which can exist in a superposition of two states. Qubits are extremely sensitive to noise and interference from their environment, which can cause them to lose their quantum properties and introduce errors into the calculation. To avoid this, qubits must be isolated and cooled to temperatures close to absolute zero, which requires sophisticated and expensive hardware, as already stated, Google has developed a quantum error correction scheme that uses multiple physical qubits to encode a single logical qubit that could then be checked and corrected for errors. Google has shown that using more qubits could reduce the error rate of quantum calculations; However, this also increased the complexity and cost of the system, as more qubits have to be connected and controlled.

Now Google has set itself a roadmap for quantum computing with six major milestones, the last of which was to build by 2029 a useful quantum computer that could solve problems that are beyond the reach of classical machines; however, Google realized that it would need millions of physical cubes to reach this goal, which was beyond its current capabilities and resources. In addition, Google was facing increasing competition from other companies and institutions that were developing their own quantum computers, for example, IBM, Microsoft, the Internet, Amazon, and Elong, so Google decided that it was not worth continuing with its quantum computer project, given the technical difficulties and uncertain market potential. The company stated that it would focus on other areas of research and innovation such as artificial intelligence, cloud computing, and biotechnology.

Google also stated that it would collaborate with other players in the quantum field and share its expertise and infrastructure. The announcement of Google's closure has sparked mixed reactions among the scientific community and the public. Some have expressed disappointment and sadness at the loss of a leader in quantum computing; while others have praised Google for its achievements and contributions to the field. Some have also questioned whether Google's decision was premature or motivated by other factors. For example, Microsoft is working on building a topological quantum computer, which uses exotic particles called anions, to encode and manipulate quantum information, this could make the quantum computer more robust and scalable, but it also requires creating and controlling the anions which is a big challenge.

On the other hand, Alibaba, is one of the major players in quantum computing in China, where the government has invested heavily in this technology, Alibaba operates a cloud-based quantum platform called Alibaba Cloud Quantum Development Kit, which provides tools and resources for quantum developers. Alibaba also collaborates with academic institutions and research labs on quantum projects. The future of quantum computing is still uncertain as there are many open questions and challenges to overcome; However, there are also many opportunities and possibilities to continue exploring and discovering, quantum computing is not dead, it is just evolving in new directions.

CONCLUSION

Quantum computers require a new technology that is revolutionizing the beginnings of this industry. Currently, there are great efforts and investments by public or private institutions and companies, such as IBM and Google. They are competing not to be left behind, publishing articles in which they announce part of their achievements in the use of this new technology. One of these milestones is "Quantum Supremacy," known as quantum advantage, which uses a real quantum computer to perform a specific task in less time than a supercomputer. The routine to solve this task is difficult to perform on a classic computer due to its physical limitations.

One of the biggest obstacles to the use of this technology is quantum decoherence, a phenomenon caused by the interaction of a physical system with the external environment. This effect causes quantum superpositions to degrade, which involves the use of statistical estimates to describe the behavior of states. These interactions are produced by physical factors such as temperature, electromagnetic noise, vibrations, etc. These are factors that are difficult to avoid completely; However, they have designed new hardware and software to make quantum coherence possible to obtain larger time intervals for system stability.

Although there are several techniques to manipulate qubits, such as trapped ions, based on the work of Cirac and Zoller, the photonics used in the Chinese computer Jiuzhang, the technique most used and employed by Google and IBM is superconductivity; However, other new possibilities are being investigated that could reduce the margin of error or limitations of current quantum computers.

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