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Quantum, Atomic and Nuclear Physics A Short Review: Quantum Computing

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Abstract—*Quantum particles when treated as computational bits can perform certain calculations exponentially faster than conventional computers while being isolated from the external environment. The Quantum computers are based on Qubits which undergo superposition may be able to efficiently solve problems which are not practically feasible on classical computers. The authors attempt to present a basic structure of Qubit and how Qubit utilizes the concept of superposition to perform calculations faster than conventional bits.*

1. INTRODUCTION

Quantum Computing utilizes the concept of quantum physics to perform different computing operations. They are based on Quantum bit (Qubit) which can perform certain calculations exponentially faster than conventional computers**.**

To perform operations on data quantum-mechanical phenomena, such as superposition and entanglement are used [9].

We begin our discussions by introducing a structure of Qubit in Section II. We describe superposition phenomena in Section III. In Section IV, a comparison is made between quantum and classical Computers. Conclusions and future directions are given in Section V.

2. QUBIT: FORMATION AND STORAGE OF INFORMATION

Quantum computers are based on quantum bits, so firstly, quantum bits are formed and then data is read or write on these bits.

Qubit can be made by using electron, photon or nucleus [8] as illustrated in fig.1

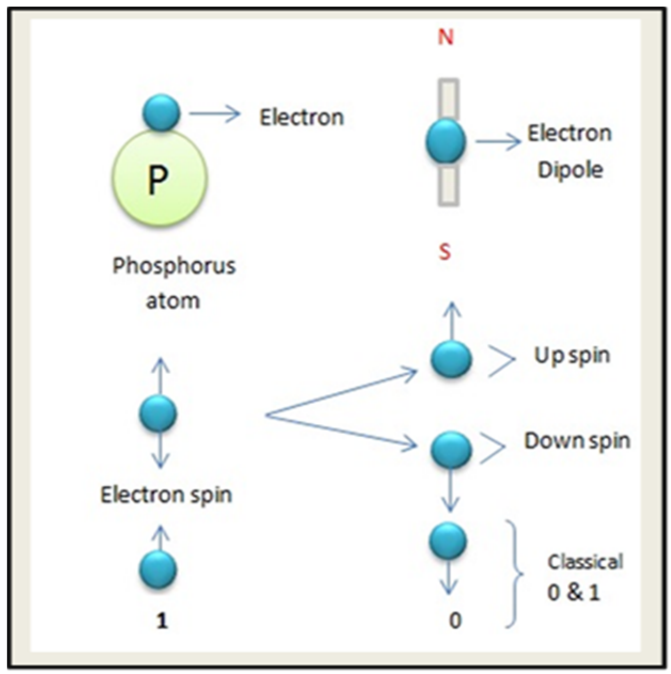

Fig. 1: Qubit is any two level quantum system such as Electron spin.

Now, to differentiate in the energy state of electron energy state, we need to apply some external force (magnetic force), we can use super conducting magnet to do this. Now, at room temperature electron continuously switch from one state to another, so initially we have to cool it down so it comes to lower energy state (0).

Now, to write information on Qubit we apply microwave pulse of specified frequency to put it into spin up state (1). Now, when electron goes from 0 to 1 state we can make it to stop at anywhere in between the two points, then that position is called Special Quantum Superposition position of the spin up and spin down [1]. To read out information we use the concept of energy that is spin down has lower energy and spin up has higher energy. If we see a positive current that electron is in spin up state and vice versa.

3. QUANTUM-MECHANICAL PHENOMENA: SUPERPOSITION

Classical computer perform operation using binary bits which can be either 0 or 1 but not both at same time, in contrast quantum computer uses Qubits which can 0 and 1 at the same time [5] which makes Quantum computer even more special. Now, as we know how physical objects can be used as Qubits whether electron, photon or nucleus.

For example- Suppose we have two bits of information, classically it can be 00, 01, 10 and 11. Here, each two bit contains only two bits of information. But, quantum computing allows us to make superposition of each one of its four state i.e. 00, 01, 10, 11. So we can write quantum state as:

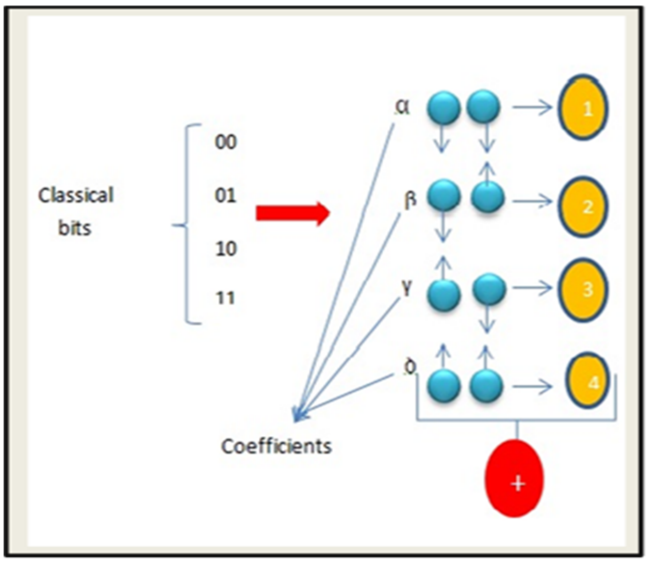

Fig. 2: Qubits undergoing superposition

So, to determine the value of one state we need four coefficients i.e. two Q-bits contain four bits of information while classical two bits contain only two bits of information. Now, 3 Q-bits (3 spins) will contain 8 bits of information .So, if we keep going we find that equivalent classical information contained by N Q-bits is equal to 2^N (power of exponential) classical bits [3].

Thus, we can see that how much more information does Q-bit contain as compared to classical bit**.**

4. QUANTUM COMPUTERS VS CLASSICAL COMPUTERS

Quantum computers are different from binary digital electronic computers as in digital computing binary digits (bits) are used to encode data each of which is always in one of two definite states (0 or 1), quantum computation uses quantum bits, which can be in superposition of states [2].

Quantum bits can take both value i.e. 0 and 1 at the same time whereas binary bits can be either 0 or 1 at one time

For example: When a coin is tossed up it will get either head or tail at one time (classical bits) but when you look at coin when it is still moving in air , it had both head and tail at same time(Qubits).

Thus, quantum computers may be able to efficiently solve problems which are not practically feasible on classical computers.

For example: To find out the prime factors of 2000 bit number, it would take classical computer millions of years but quantum computer will be able to do this in minutes, since it based on Qubits that takes advantage of quantum superposition to reduce the number of steps [6,7]. Hence, Quantum computers have superior computing power as compared to classical computers.

It may be mentioned that Quantum computers are not universally faster. They are fast for special types of calculations where you can use the concept of quantum superposition. So here, the improvement is not in the speed of individual operations but is in the total no of operations you need to arrive on result.

5. CONCLUSION AND FUTURE DIRECTIONS

This paper provides basic structure of Qubit and how Qubit utilizes the concept of superposition. By utilizing this concept quantum computers perform calculations faster than conventional computers. Thus, these computers might prove useful in areas which are not assessable to classical computers. As of now, the development of actual quantum computers is still in its early stage being researched by industry and academia so that the benefits of quantum computers is extended to civilians, business enterprises, national security(crypto analysis) [4] as well as scientific applications.

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