Quantum Technology and the Next Generation Computers

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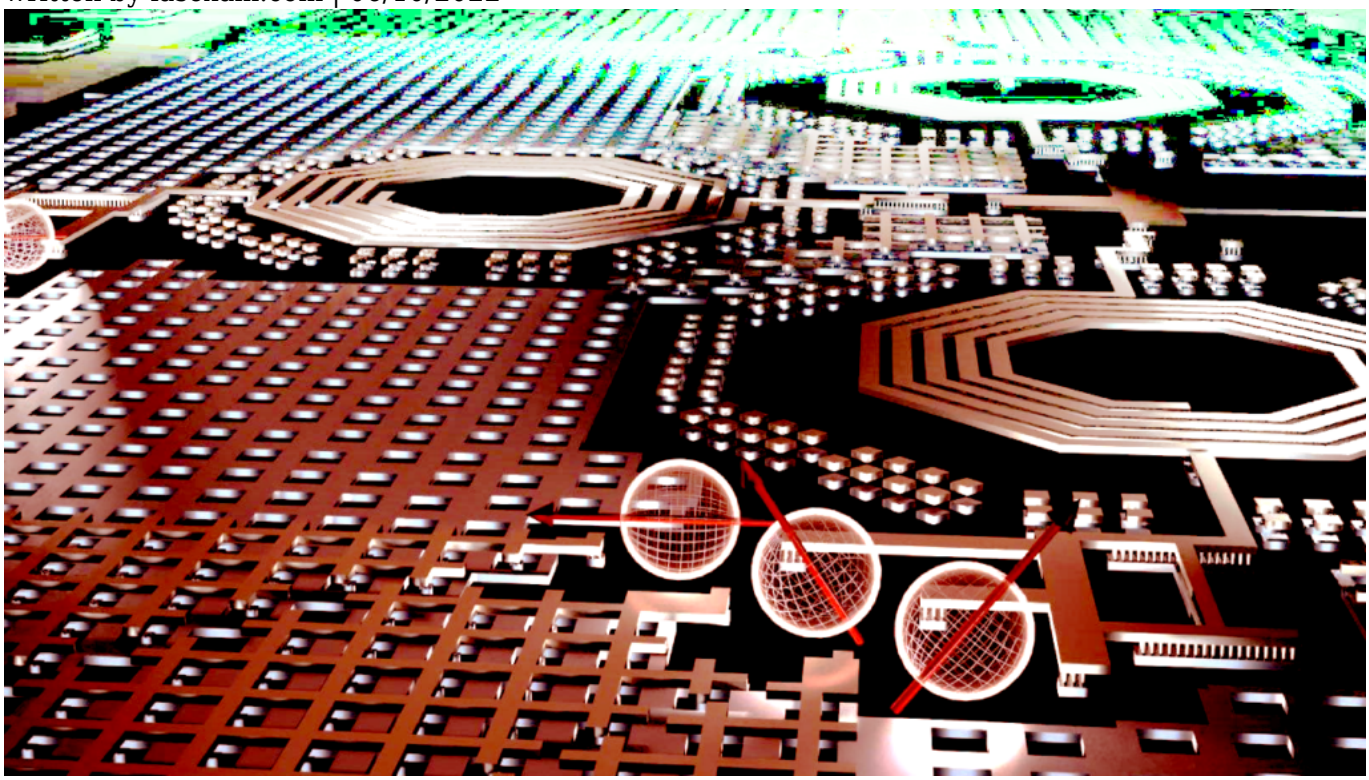

[GS Paper 3 – Awareness in the field of IT, Space, Computers, Robotics]

Context – Three scientists Alain Aspect of France, John Clauser of the US, and Anton Zeilinger of Austria are set to be honored by the Nobel Prize Committee for their work in domain quantum physics.

These scientists have made incredible contributions to not just the foundations of quantum theory but also to efforts that have now enabled the possibility of a wide range of applications. The experiments conducted by them have conclusively established that the 'entanglement' phenomenon observed in quantum particles was real, not a result of any 'hidden' or unknown forces.

About Quantum Theory

- It is a fundamental theory in physics that provides a description of the physical properties of nature at the scale of atoms and subatomic particles.The Quantum Theory is the foundation of all quantum physics including quantum chemistry, quantum field theory, quantum technology, and quantum information science.

- The principles of Quantum mechanics are different from that of classical physics in energy, momentum, angular momentum.

Development in Quantum Theory

- Planck's assumption: Max Planck in the year 1900 had made the assumption that energy was made of individual units.

- Albert Einstein's theory : Albert Einstein in the year put forward that not just the energy, but the radiation itself was quantized in the same manner.

- Louis de Broglie theory Louis de Broglie in 1924 theorized that there is no fundamental difference in the makeup and behavior of energy and matter either on the atomic or subatomic level and either of them may behave as if made of either particles or waves. This theory was termed as the principle of wave particle duality from there on where it is proposed that the elementary particles of both energy and matter behave, depending on either the particles or the waves (wave-particle duality).

- Heisenberg Principle: Werner Heisenberg in the year 1927 proposed that precise, simultaneous measurement of two complementary values – such as the position and momentum of a subatomic particle – is impossible. In contrast to the principles of Classical Physics, their simultaneous measurement is inescapably flawed; the more precisely one value is measured, the more flawed will be the measurement of the other value. This theory was later on termed as the uncertainty principle, which prompted Albert Einstein's famous comment, "God does not play dice."

Entanglement and Superposition

- One of the several weird properties exhibited by these tiny particles is the Entanglement. The property suggests that, two particles, having 'interacted' with each other at some stage, were found to have got 'entangled' in a way that the behavior of particle produced a reaction in the other almost instantly even if the two were no longer connected in any way and were separated by very large distances.

- In order to open up new technological possibilities, the entanglement property was proposed. For the very first time it became possible to 'teleport' the quantum states of a particle to another location without the particle moving anywhere and without a medium.

- Superposition is a phenomenon where a particle exists simultaneously at multiple locations. The probability of finding the particle at any particular place was dictated by

probabilistic calculations, and once it was found, or observed, at one location, it ceased to exist at all other places.

Einstein's Assessment

- Einstein's Special Theory of Relativity restricted any signal from traveling faster than the speed of light. These principles of Quantum Physics where there was seemingly instantaneous communication due to entanglement had the danger of further unraveling the foundations of physics.

- He described the strange behavior by quantum particles as 'spooky'.

- One of the major concerns of Albert Einstein was that the entanglement property allows for transmission of information at speeds faster than light, and was not entirely accurate.Einstein further elaborated that, when an operation is performed on one of the entangled particles, there is an instantaneous reaction in the other.

- The observer at the other end had no way to know that the reaction had occurred. He had to be specifically made aware of the operation having been performed, and it happened only through classical communication channels limited by the speed of light restriction.

Conclusion

The entanglement property in present times is being utilized to build the next generation of computers known as quantum computers, which can exploit the quantum behavior of particles to overcome challenges considered as insurmountable.Th property is being put to use to create secure communication algorithms that would be immune to hacking.