The Quest For The Grand Unification: The Theory Of Everything

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Have you ever imagined what those equations in the high school textbooks of physics really mean!! What is the significance of the Newton's three laws of motion and Law of Gravity or why the equations in the chapters on electricity and magnetism are so important in science? Stuck at completing the syllabus in a short period of time we often miss the grasp of these otherwise interesting things. Could you imagine a universe where an apple falls from the tree not in a straight line but in a zigzag path or it could may move upward or even sideward. But why in our universe it falls in a straight line only. No matter where we go in our universe it happens exactly the same everywhere. We studied that same charges repel and opposite attracts. Why couldn't it be the reverse? I.e. why can't same charges attract and opposite repel? By carefully observing these mysteries we can say that our universe follows some definite patterns. What the physicists do is just unravel these laws in the form of equations using the beautiful tool of mathematics. Newton's equation of gravity holds accurate everywhere except the microscopic world. The four equations of Maxwell on electromagnetism can explain all the electromagnetic phenomena in our universe.

A Black Hole Curves the Space into an Infinitely Deep Hole

Towards the later years of his life Albert Einstein had got hold of a bizarre pattern in the laws of physics. Maxwell had unified electricity and magnetism into four simple equations that can explain all the phenomena that are electromagnetic in nature. Newton showed that his equation of gravity can be used to explain the falling of a fruit from a tree and also the revolution of a celestial body around another celestial body i.e. he unified the celestial with the terrestrial. Einstein was deeply inspired by this idea of unification. Einstein had a feather in his cap in the name of General Relativity (1915). In this theory Einstein disproved the Newtonian concept of gravity. Newton's explanation says that if the sun disappears suddenly then all the planets are disconnected from the gravitational attraction of sun and will start moving in a tangential path towards infinity. Newton says that it happens instantaneously. But according to Einstein's Special Theory of Relativity (1905) nothing can move faster than light. The question arose, how could the effect of the absence of sun reach the planets instantaneously as nothing can move faster than light? So, Einstein came up with a new idea with a satisfactory mechanism to explain how gravity works. Einstein said that massive objects curves space in a same way a metal ball stretches the trampoline downwards. It is in this curve planets move around the sun. Now this can make a sense to explain what happens if sun disappears. The disappearance of the sun causes a disturbance in the space and waves of gravity are generated which moves towards the planets and the

planets experiences the absence of sun only when the gravity wave reaches the planet. Einstein even calculated the speed of the waves which was exactly the same as that of light. This wave is known as Gravitational Wave (GW) which was discovered in the Laser Interferometer Gravitational-Wave Observatory (LIGO) situated in Louisiana in United States on 11th Feb, 2016. The equality of the speed of the GW with light which is electromagnetic in nature got the attention of Einstein. Einstein believed that there must be a connection between Gravity and Electromagnetism. Einstein spent later period of his life in search of a theory which could unite these two fundamental forces into a single piece of master equation. But the 3rd decade of the twentieth century seemed to shatter Einstein's dream of unification. The laws of Quantum Mechanics discovered in this time showed that the nature deep in the atomic scale behaves in a completely different way which is counterintuitive to our daily experience. It is impossible to understand the atomic world in terms of our experience of day to day life. We cannot say where an electron is definitely before we look for it; it could be anywhere in the universe with varying probability. It means that the atomic world is not deterministic, it is probabilistic. Quantum Mechanics gave birth to the two more fundamental forces of universe i.e. Strong Nuclear Force and Weak Nuclear Force. Strong Nuclear Force binds the neutrons to the protons in the nucleus of an atom and Weak Nuclear Force allows neutrons to turn into protons giving off radiation in the process which is responsible for the radioactivity of some elements. The Strong Nuclear Force is Strongest and The Gravitational force is the weakest in strength. Hence, with these four forces we can summarize all the laws of our universe. With further advancement in Quantum Mechanics the three forces i.e. Electromagnetism, Strong Nuclear Force and Weak Nuclear Force were unified into a single theory namely The Unified Field Theory. Sheldon Glashow, Abdus Salam and Steven Weinberg were awarded Nobel Prize in Physics in 1979 for their outstanding work for the development of the Unified Field Theory. This theory presents a Standard Model of the universe where the effect of these forces are carried through the exchange of some carrier particles called Gauge Bosons. The exchange particle that carries the Strong Nuclear Force is Gluon while that of Weak Nuclear Force is W and Z Bosons and Photon for Electromagnetism which are well established and experimentally proved. The Modern Unified Field Theory postulates Graviton as a hypothetical carrier particle for Gravitational Force. Though Unified Field Theory was highly successful in unifying the three forces into a single theory in terms of the laws of Quantum Mechanics, Gravitation seemed hard to fit into this theory. Einstein's General Relativity does not work in the atomic world i.e. it is yet not clear how gravity works in the quantum level. Thus, the challenge is to unify the law of the bigs to the law of the smalls. The theory which can explain gravity in terms of the laws of Quantum Mechanics is known as The Theory of Everything i.e. a theory that combines all the four fundamental forces of the universe into a single master equation. But what is the significance of explaining General Relativity in terms of Quantum Mechanics? The answer to this question lies in the region of the monster of space, Black Holes. Black Holes are super dense as well as tiny regions in space where the gravity of the mass is so much strong that it curves the

space into an infinitely deep hole and nothing, even light cannot escape it. It is a region with very large mass and very small size. Both General Relativity and Quantum Mechanics gives non sensible results in this region. But the universe is not a non-sensible place. Thus a unification of the two theories is a must to explain our universe in a satisfactory manner.

Geometric Representation of the Hypothetical Multiple Dimensions Of Space in String Theory

There are a few possible candidates for The Theory of Everything namely the String Theory and Loop Quantum Gravity, but String Theory is the promising one which is highly accepted and studied. In this theory the fundamental particles of physics are assumed to be some extremely small one dimensional vibrating strings of energy. Just as the different frequencies of the violin gives different sounds, different frequencies of these strings characterizes different particle of nature. Thus String Theory explains the universe as a cosmic symphony resonating with all the various nodes. But explaining this theory requires a universe with eleven dimensions. Till now four dimensions of the universe is known to human kind. But where are the rest seven dimensions!! One probable answer to this question is that these dimensions are so small that matter of large size like human body cannot move in these dimensions. On a wire of electricity, we see only one dimension. But as we look close to it there is a curved surface of it around which an ant can move easily, but we humans cannot.

The problem in String Theory is that the size of the strings is so small that it cannot be detected even with the strongest particle accelerator (Large Hadron Collider) built till now. Neither can anyone disprove it. Hence, there is still a scope in this domain. With future development we may one day be able to detect these strings of energy and have a Theory of Everything. We would be able to describe whole of our universe with a single equation; the beauty, the elegance, the majesty of the universe into a single equation!!