International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.43

Is Quantum Gravity the Ultimate Theory? Is it the Theory of Everything or the Unification of Physics?

Prasenjit Debnath

PhD Student, NIT Agartala, Tripura, India

Abstract: ***The extraordinary scientific breakthroughs, particularly Sir Isaac Newton's theory of Gravity, had led Marquis de Laplace to analyze and predict at the beginning of Nineteenth century that the Universe is completely deterministic. Laplace believed that given a set of initial states or conditions (such as the present states or conditions of the Universe) or the boundary conditions (i.e. the conditions at the boundary of either space or time or space-time, if any, of the Universe) of the Universe, the future states of the Universe can be completely specified for any given particular time in the future i.e. at least in principle, we can predict accurately everything that would happen in the Universe. The only excitation or input required in the Laplace's model of the Universe is that the complete states of the Universe at any particular given time. A boundary condition in space is the state of the Universe at its outer boundary-if any. Based on the total set of laws with appropriate initial or boundary conditions, according to Laplace, we can calculate the complete states of the Universe at any given time in the future. The problems with finding the initial conditions or boundary conditions are many. The two most influential theories in the physical science are the Einstein's the general theory of relativity which represents the macroscopic structure of the Universe very accurately without any fail with observations and the quantum mechanics which describe the microscopic structure of the Universe within the limits of uncertainty principle, it supports all observations without fail of any. The recent trend is that to incorporate gravity in the quantum mechanics to develop a complete theory-the theory of quantum gravity that will describe all possible observations regardless of macroscopic and microscopic structural differences of the Universe. Is that the quantum gravity, if any, will be the ultimate theory of physical science? Is unification of physics is possible with quantum gravity? Is the quantum gravity will be the theory of everything? Or is it the end in sight for the theoretical Physics? What should be and must be the main ingredients of such unification of physical science? The long standing quests need to be addressed in the process of finding the ultimate theory-the theory of everything to obtain the unification of physics.***

Keywords: The quantum gravity, uncertainty principle, initial and boundary conditions, the general theory of relativity, deterministic Universe.

1. Introduction

The requirement of the initial conditions is probably intuitively obvious: the different states of being at present of the Universe can be regarded as initial conditions of the Universe to predict future states [1]. The principle is the same for boundary conditions in space or time but a bit more subtle [2]. The equations in which the physical theories are based on do generally have very different solutions every time [3] and that is where we have to rely on initial conditions or boundary conditions to decide which solution is the ultimate solution that corresponds to the physical Universe. For example, if we say, you have a large amount transferred in your account, now to decide whether you become bankrupt or rich, we need not only the information of the sum going out or in, but also we need information of the sum in your account before the bank transfer. Suppose Laplace is right, then the complete sets of present states of the Universe will determine the future states of the Universe as well as the past states of the Universe of a given particular time [4, 5]. For a given position and velocity of all the planets and the sun in our solar system [6], we can calculate the positions and velocity of the planets and sun at any time in the past or the future with Newton's Laws of physics. The theory of determinism seems to be very obvious for the solar system [7]. It is because we can have very accurate predictions of present states of the solar system with highly powerful telescopes and computational power of computers for calculations [8, 9]. The problems start with microscopic structure of the Universe, even a glass of water contains more than 10^{24} molecules, (a 1 followed by 24 zeroes) [10, 11], in practice, we can never know the state of each molecule which is much less in complexity with respect to our body or, in general, to the Universe [12]. Yet to say, as our past is one and unique due to causal structure of the physical time, the future must be one and unique too due to anti-causal structure of the physical time, because they are related in a cause and effect relationship, both are mutually dependent on each other, if past is one and unique, so is the other one, the future. Mutual dependency in the sense that, as future is responsible for the past to exist as one and unique, the same way past is also responsible for the future to exist as one and unique too. Future and past interact with each other with the abstract present. A present can be an illusion, mere a psychological interaction with the physical time. So, the Universe is deterministic, even we do not have the brain power to do the calculations required for the initial states on particular cases, our future is nevertheless predetermined and preordained. So, Laplace was pioneer in predicting the deterministic Universe, and the theory of determinism is certainly valid and appropriate model of the Universe. The theory of determinism might not be the theory of everything, but it can be a partial theory that is unavoidable in the quest on ultimate theory and can hold a part in building the ultimate theory. Although, this doctrine of determinism was strongly resisted by many people including scientific community, but it retained as standard assumption for a long time. Initially, it was believed that the black body radiation given off by hot bodies as electromagnetic waves has equal energy for all frequencies. As frequency of the radiation increases, so is its energy content which indicates that the sum of energy of total radiation must be infinity and it must obviously be a ridiculous result. So, Max Planck corrected the infinity to a

finite value by suggesting that electromagnetic radiation from a hot body, i.e. the black body radiation comes in a packet which he termed as quanta like, for example, a quantum light of photon. The higher is the frequency of the radiation, the greater is the energy content in it. Because the black body must radiate a finite amount of energy, at higher frequencies, the quanta gets lower and lower in amount and at certain very high frequency (critical frequency), the black body must stop its radiation above the critical frequency so that to meet the requirement of finite energy radiation. The quantum hypothesis explained the variation in rate of emission of electromagnetic radiation with frequency very well [13] but how its implication on the determinism can be realized? [14] Any finite quantity of radiation process can be mathematically explained and it must be not very hard to find the maximum frequency possible for electromagnetic radiation [15]. Once the maximum frequency reached, there will not be any further electromagnetic radiation above the maximum critical frequency.

2. The Implication of Uncertainty Principle on Determinism

One of the first indications that the belief of determinism had to be abandoned is the implication of uncertainty principle [16]. The very famous uncertainty principle, on contrary of Laplace's belief of determinism, tells us that nature put limits on our ability to predict future. The more accurately we measure the position of a particle, the less accuracy we end up with the velocity of the given particle [17, 18]. Even (as small as) one quanta of light will disturb a particle to change its velocity in such a way that we will be erroneous in predicting the velocity of that particle. The higher is the amount of photon, the greater is the perturbation of the particle. The uncertainty in the position times the uncertainty of the velocity times its mass can never be less than a critical fixed value which is termed as Planck's constant and it is a very very tiny number [19]. It implies that if we double the accuracy of the position of the particle by bombarding twice more quanta of photon on the particle, we will end up with half accuracy with its velocity as the perturbation increased due to extra photon and vice versa. According to uncertainty principle, nature forever constrains us to making this trade-off. It is so tiny the trade-off that the quantum theory, in general, very much like the effects of the general theory of relativity, not directly noticeable in everyday life. Is uncertainty principle is a fundamental, inescapable property of the Universe? [20] Is the uncertainty principle put an end to the dream of Laplace of deterministic Universe? It might have profound implications on our view of the Universe, but a particle's position and its velocity is not a function of our psychological measurement. In other words, the particle has nothing to do with our measurement of its velocity and position. The way how we measure position and velocity can never be a principle such as uncertainty principle. A principle must be universal truth at least within the limits of our psychology. The inability in measurement of both position and velocity simultaneously of a particle can never be termed as principle. Is that nature put limits on us or we yet to find right type of measurement to meet particles original deterministic behavior-the speed and its position? Why we do use term 'nature put limits' to hide our inability to predict the position and velocity at a time? If we have as rough measurement of the velocity of an electron confined in an atom as plus or minus one thousand kilometers per second, why we blame nature for that? If causality makes past as fixed like a permanently sealed box, so is the future of us. So, all seemingly random processes supported by uncertainty principle are all well-defined processes by nature to meet fixed future. If future is one and unique, what the reason is to use probability on events of future and not on past. Only we came to know the fixedness of the future when it passes through abstract present to become past. It is a lame excuse of the uncertainty principle that how we can predict future if cannot measure the state of the universe at present very precisely. Many things our own machine does, which we cannot do. So, there can be a machine that does measure the position and velocity of a particle at a time accurately, just we need miles to go to develop tools and algorithms that a machine needs for that. So, the uncertainty principle can never signaled an end of Laplace's dream of a theory of science, a model of the Universe that would be completely deterministic. After all a well-defined past and future must have all the property intact for every event to be deterministic which describes position and velocity of a particle, thus these must be well-defined as well. A cut out of uncertainty principle needed to develop the ultimate theory-the theory of everything or the unification of physics.

3. The Implication of Quantum Mechanics on Determinism

A short cut is like cut out all the features of the theory that cannot be directly or indirectly observable. This approach led Heisenberg, Erwin Schrodinger, Paul Dirac in the 1920s to formulate Newton's mechanics into a new theory called quantum mechanics which is based on uncertainty principle [21]. In this theory, the particles do not have well defined velocity or position. Instead, they have quantum state which is a combination of position and velocity defined within the limits of the uncertainty principle [22]. But on a definite future i.e. one and unique future, the uncertainty is purely psychological, and uncertainty is certainly naïve. It is like thrown an event to have either result possible a yes or a no. Uncertainty principle is seemingly right because of inability to anticipate one and unique future. Without proper mathematical tool, all we can do is to guess future most likely to be. Future is exactly similar to past. Future is a past on a time reverse scale and vice versa. If past and future are flipped side of the same coin [23], there is no reason to accept one as definite because we know it and the other one as probabilistic as we do not know it. As quantum mechanics is based on probabilistic uncertainty principle, therefore, it should not be in the theory of everything or in the unification of physics. As long as we do not have definite prediction of future, it is better to leave future as future as it is. Therefore, as quantum mechanics introduces unpredictability or randomness into the science that might be seemingly true, but never an absolute truth in deterministic past and future and must be discarded from the ultimate theory - the theory of everything or unification of physics because it only means quantum mechanics limits science and science is not limited, it must grow like anything forever.

4. The Implication of the General Theory of Relativity on Unification of Physics

The general theory of relativity can be regarded as partial theory in the unification of physics as it breaks down on points of infinite density-singularities [24]. Singularity occurs when an enormous mass and energy is squeezed into a small enough volume thus displaying infinite density. The general theory of relativity can never answer the beginning of the Universe unless it is refined or modified to include singularity. Thus it predicts its own downfall and need to be modified or altered to accommodate into the theory of everything or the unification of physics. Then why this theory never fails in any experiment? The reason is that we experience a very weak gravitational field around us where the gravitational force is so weak, the general theory of relativity holds good enough to support observations in such an environment. But the problem starts when huge mass and energy squeezed into a small volume such as the early universe of infinite density- in that, the general theory of relativity breaks down into singularities. But the theory is a good partial theory and can be considered a place in the theory of everything or in unification of physics.

5. Is Quantum Gravity Feasible?

There is no place of uncertainty principle or the quantum mechanics in the model of the deterministic Universe. The theory of determinism holds good to be part of the unification of physics. Just we need to find ways to determine initial states or boundary conditions of the Universe. Sum over histories is just extension of the quantum mechanics and must be excluded from the unification of physics. A one and unique history cannot have alternative histories or sum over histories. Thus, quantum gravity might be a seemingly feasible idea but will not be a correct idea because of incorporation of uncertainty principle..

6. Conclusion

Though, we do not have yet the ultimate theory i.e. the theory of everything to reach the goal of unification of physics. But we can have some ideas of incorporating some partial theories in it. One must be the theory of determinism that predicts one and unique past and one and unique future. It can incorporate Laplace idea of a deterministic Universe. It can incorporate the wave propagation as massless photon travels through space as wave which indicates space is not flat but approximately sinusoidal curly. The space is as curly as wave's crest and through. Massless photon responds to curly space with maximum deviation possible. As it has no mass and hence no gravity of itself. Masses also propagate through curly space with minimum deviation possible. If Einstein is correct, a curved space-time can be incorporated in the unification of physics. A curved space–time indicates that we will never have boundary states or conditions of the Universe because a curvature, like circle, never has an end. In that case we have to assume that the boundary condition of the Universe is that it has no boundary. Classical mechanics made its own downfall by predicting infinite energy in black body radiation of a hot body. It is not a bad assumption that the Universe can be self-contained and does not need outside perturbation. But certainly uncertainty principle has nothing to do with predetermined or preordained Universe with definite past and definite future; there is no place of probability or uncertainty because "God does not play dice".

7. Acknowledgment

I cordially admire **Dr. Aparna Nath**, Associate Professor and my PhD Guide, The department of Physics, National Institute of Technology, Agartala, India, for the epitome of inspiration and motivation to write this particular paper with perfection and accuracy. I am extremely thankful to her from all possible help she made to write this paper. Also I am thankful to The Department of Physics of National Institute Of Technology Agartala (NIT Agartala) for proper conduct and coordination and optimistic approach.

References

[1] Stephen Hawking, "A Briefer History of Time", Bantam Books, London, pp. 1-105.
[2] Stephen Hawking, "Black holes and Baby Universes and other essays", Bantam Press, London 2013, ISBN 978-0-553-40663-4
[3] Stephen Hawking, "The Grand Design", Bantam Books, London 2011
[4] Stephen Hawking, "A Brief History of Time", Bantam Books, London 2011, pp. 156-157. ISBN-978-0-553-10953-5
[5] Stephen Hawking, "The Universe in a Nutshell", Bantam Press, London 2013, pp. 58-61, 63, 82-85, 90-94, 99, 196. ISBN 0-553-80202-X
[6] Stephen Hawking, "The Beginning of Time", A Lecture.
[7] Stephen Hawking, "Stephen Hawking's Universe: Strange Stuff Explained", PBS site on imaginary time.
[8] Gerald D. Mahan, "Many-Particle Physics", Third Edition, Springer, 2000
[9] Uno Ingard, K "Fundamental of Waves & oscillations", Cambridge University Press. P. 38, ISBN-0-521-33957-XOxford: The British Academy, 1999
[10] A. Zee, "Quantum Field Theory in a Nutshell", Princeton University Press, 2003
[11] Storrs McCall, "A Model of the Universe", Oxford: Clarendon Press, 1994
[12] Craig Callender, "Time, Reality and Experience", Cambridge, UK: Cambridge University Press.
[13] Craig Callender, "Thermodynamic Asymmetry in Time", The Stanford Encyclopedia of Philosophy (Spring 2002 Edition)
[14] Storrs McCall, "A Model of the Universe", Oxford: Clarendon Press, 1994
[15] Robin Le Poidevin and Murray McBeath, "The Philosophy of Time" Oxford: Oxford University Press, 1993
[16] Newton-Smith, W.H., "The Structure of Time". London: Routledge & Kegan Paul, 1980.
[17] Barry Dainton,"Time and Space", Ithaca: McGill-Queen's University Press, 2001
[18] Robin Le Poidevin, "Questions of Time and Tense", Oxford: Oxford University Press, 1998.

[19] Nerhlich, Graham, "What Spacetime Explains". Cambridge: Cambridge University Press, 1994.
[20] Sklar, Lawrence, "Space, Time, and Space-time". CA: University of California Press, 1974.
[21] Whitrow, G., "The Natural Philosophy of Time". Oxford: Oxford University Press, 1961. (2nd edn., 1980.)
[22] Smart, J. J. C., "Problems of Space and Time". London: Macmillan, 1964
[23] Stephen Hawking, "A stubbornly persistent illusion- The essential scientific works of Albert Einstein", Running Press Book Publishers, Philadelphia, London 2011.
[24] William L.Craig, "Time and the Metaphysics of Relativity", Dordrecht: Kluwer Academic Publisher, 2001

Author Profile

Prasenjit Debnath, born in Agartala, Tripura, India on 15th of March 1979. He is pursuing a PhD degree in the Department of Physics in National Institute of Technology Agartala (NIT Agartala), India.