“On the Probabilistic Nature of Observable Phenomena”.

Muhammad Ali

Warsaw University of Technology, Poland

Email: alinaeem023@hotmail.com

Abstract:

This paper proposes a Gadenkan experiment named “Observer’s Dilemma”, to investigate the probabilistic nature of observable phenomena. It has been reasoned that probabilistic nature in, otherwise uniquely deterministic phenomena can be introduced due to lack of information of underlying governing laws. Through theoretical consequences of the experiment, concepts of ‘Absolute Complete’ and ‘Observably Complete” theories have been introduced. Furthermore, nature of reality being ‘absolute’ and ‘observable’ have been discussed along with the possibility of multiple realities being true for observer. In addition, certain aspects of quantum mechanics have been interpreted. It has been argued that quantum mechanics is an ‘observably complete’ theory and its nature is to give probabilistic predictions. Lastly, it has been argued that “Everettian - Many world” interpretation of quantum mechanics is very real and true in the framework of ‘observable nature of reality’, for humans.

1. Introduction

Understanding the very nature of reality and observable phenomena is the most fundamental of questions in Physics. Physicists therefore theorize these phenomena with mathematically sound theories, predicting outcome of these phenomena, which are then tested experimentally. Subsequently, these predictions are very helpful in understanding the nature of reality. Among these observable phenomena, some are probabilistic in nature, such as quantum mechanical phenomena, where predictive outcomes are uncertain. Physicists therefore argue about the completeness of quantum mechanics and in ability to give unique deterministic prediction, and hidden variable theories such as Bohm's hidden variable theory[1] are proposed. In addition, very often testing these predictions become an experimental challenge, on the basis of technology and measurement processes. To serve this purpose, Gadenkan or thought experiments are more often used for the purpose of thinking through their consequences. In Physics, these experiments are useful tools to investigate the nature of reality, by exploring the potential theoretical consequences of the experiment.

One such Gadenkan experiment, named "Observer's Dilemma" is suggested in this paper. The purpose of "Observer's Dilemma" is to investigate the nature of observable phenomena and to reason that uncertainty in otherwise uniquely deterministic observable phenomena can be introduced, on the basis of lack of information of governing laws or inability to make measurements. Information in this context, means data about the phenomena, observable or otherwise unobservable, measureable or unmeasurable. Theoretical consequences of observer's dilemma presents a strong arguments on the completeness of theories, possibility of multiple realities and the very nature of reality. Furthermore, on the premise of these consequences, some

fundamental aspects of quantum mechanics are interpreted, such as its nature, completeness and Everettian Interpretation of Quantum Mechanics.

2. Observer's Dilemma

"Observer's Dilemma" thought experiment incorporates classical physics phenomena, such as speed of light, slowing of light speed[2], near light speed travel and basic observational astronomy concepts. For this experiment, consider three individuals Jia, Alice and Bob. The roles of these individuals are as follows:

Jia – Experimentalist. She sets up the experiment, controls all the information, from deciding the rules and governing laws to be used. She also gives instructions to both Alice and Bob.

Bob – Astronaut

Alice – Observer

Jia is independent of the experiment, while Alice and Bob are part of the experiment.

Setup:-

Consider a vacuum space with two distinct spatial locations A and B. Locations A and B have physically same properties; are dimensionally exact size; are astronomically large and considerable distance apart. Location C is the observatory which is equidistant from both A and B. From the observatory, two state of the art telescopes 1 and 2 with infinity large focus are focusing on the local points of A1 and B1 of A and B, respectively. Geometrically, the origins of Local coordinates

are taken in the center of both locations A and B. Local points A1 and B1 are located at the origin of both locations A and B, as shown in figure 1.

Instructions for Bob: Travel to local point A1 of A, where telescope 1 is focusing, eject from the space craft and pose. He is then instructed to travel to local point B1 of B and give an exact pose, and then leave location B.

Instructions for Alice: Observe and report at which point Bob is.

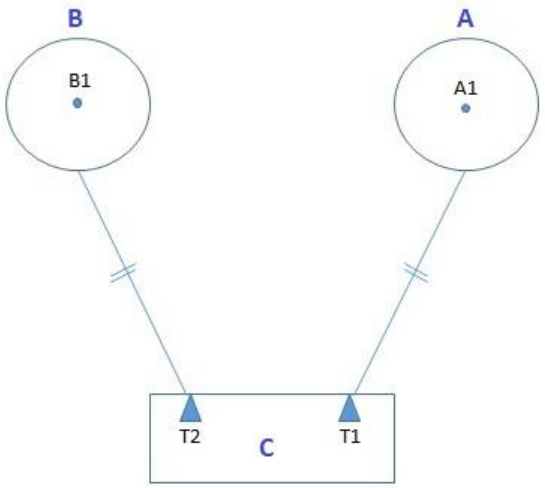

Figure 1:- Schematic Setup of the thought Experiment

Execution:

As instructed, Bob went to local point A1 of A and posed. Subsequently, went to local point B1 of B, posed similarly and left location B. All the parameters were controlled by only Jia, from spacecraft's speed which is travelling near speed of light, distances between both locations, time spent by Bob at both locations. Basic concepts of observational astronomy suggests that

electromagnetic waves of light from both local points will travel to observatory at location C, where Alice will make her observation and report. However, Jia precisely slowed the speed of light emitted from location A to a certain amount. Meanwhile, Bob went to location B, and similarly light started travelling to observatory. The value of slowing of light at location A was so precise that it took exact same time to reach the observatory as the light from B, with Bob's presence. On the observatory C, Alice was given the distances of both locations A and B, local points A1 and B1, speed of light, vacuum condition. However, she didn't know Bob's travel logs and most importantly, she was unaware of the slowing of light speed at location A. Now, using only the information she has, she has to make an observation of Bob's location.

Results:

Since light from both locations with Bob's presence reached the observatory at the same time. Alice with the provided information and inability to acquire further information, she can only tell that Bob is located at both local points A1 and A2 of locations A and B, simultaneously. For her, both realities are real and true. She cannot tell with the information she has, which reality is true and at this instance both these realities are true for her. In normalized probabilistic terms, if she wants to make unique prediction, she can only say that Bob is located at A or B with ½ uncertainty. In other words, Alice is in the dilemma of making uniquely deterministic observation. However, for Jia only one reality is true and she can uniquely determine Bob's location. This results signifies the importance of information of the underlying governing laws and for Alice, otherwise deterministic phenomenon in this case, location of a person, has become probabilistic.

3. Theoretical Consequences of Observer's Dilemma

3.1 Completeness of Theory

In general, the purpose of any theory is to predict the outcome of any phenomenon. In Physics, a theory is considered complete and closed, if it uniquely determines the values of all its measureable properties[3]. Using this concept, if Alice and Jia were to develop a theory for the prediction of Bob's location. The nature of two theories will be different.

Jia's Theory:

For this particular case, Jia has complete information of all the underlying phenomena required to predict Bob's location. If Jia were to develop a theory, the prediction of Bob's location will be unique, with 100 % certainty. Furthermore, one can argue theory is deterministic, and for this scenario, the theory is closed and complete.

Alice's Theory:

If Alice were to develop a theory, with incomplete information of the underlying phenomena and inability to make measurements, her theory will be probabilistic in nature, and uncertainty will be involved. For this particular scenario, the certainty of prediction is 50 %, and Bob's location is not unique deterministic. If one follows the definition of completeness mentioned above, one can logically say that Alice's theory is incomplete.

Absolute Completeness and Observable Completeness:

However, Alice can argue and claim that her theory is complete and closed with the information she has and her inability to make any further measurements or observations. Furthermore, she is convinced she is not allowed or cannot acquire further information. Using this premise, one can

argue, completeness of theory is based on perspective of theorist or observer. From Alice's perspective, her theory is complete and from Jia's perspective Alice's theory is incomplete. To facilitate both perspectives, the concepts of Absolute Completeness and Observable completeness become a necessity.

Let X be a certain phenomenon, further let X depends on certain number of variables (V_1,…,Vn). If all these variables can be measured and observed, or in other words complete information is available. If a theorist were to develop a theory and could measure every variable individually or in combination, the resulting theory will be Absolute Complete and the predictions will be 100 % certain. In this particular situation, Jia's theory is "Absolute Complete".

In comparison, if some of these variables are not observable and cannot be measured for any reason whatsoever, and theorist is convinced that he/she cannot any further information, the predictions of the theory will be uncertain or probabilistic, but from theorist's perspective, with the available information he/she has, it is complete and so, one can say the theory is "Observably Complete".

Logical reasoning then suggests that if the theory is "Absolute Complete", it has to be "Observably Complete" as well. The predictions will be certain and uniquely deterministic. However, if the theory is "Observably Complete", it will not necessarily give unique, completely deterministic solutions, and is allowed to give probabilistic solutions. But from the perspective and observable experience of theorist, it is complete. Obviously, theorist can argue that probabilistic nature of solutions is because of some hidden variables or information, which is not acquirable. The theory is complete from theorist's perspective, or "Observably Complete", universally.

3.2 Interpretation of Infinite number of Realities:

Above thought experiment can be altered to interpret the infinite number of realities for the observer. In the above setup, instead of two locations, suppose there be infinite number of locations.

Let infinite number of locations be $\{L_{1,}\ldots Ln\}$ with infinity number of local points $\{P_1,\ldots.P_n\}$ and correspondingly there are infinite number of telescopes $\{T_1,\ldots.T_n\}$ on the observatory C. These locations can be any distance apart, but the principle of slowing of light remain consistent such that light waves reach the corresponding telescopes at the same time. Bob's and Alice's tasks are the same as mentioned in section 2. However, Alice has the ability to observe all the telescopes at the same time. Based on the information Alice has, she will observe infinite number of Bobs, and for her all these realities will exactly be same.

Now, we have another astronaut named Naeem. His task is to do the same job as Bob's, but at each local point, he has to give slightly different poses. In this case, Alice will observe infinite number of Naeems, but since Naeem is doing a different pose at each local point, the realities will be different. In other words, one can argue, infinite number of different parallel realities exist in this case, for the observer Alice.

This thought experiment can be further altered by changing the infinite number of locations to the infinite number of Universes. By the same logic, Alice will observe infinite number of Universes, if she can, where realities can be same or different, based on the underlying laws. However, for Jia – the experimentalist, one and only one reality is true. Based only on this scenario and all the information, if Jia can develop a theory, that theory will be "Absolute Complete", with one only true reality and without uncertainty. However, if Alice developed a theory, based on the

information she has, that theory will be “Observably Complete”, probabilistic with uncertainty in the solutions. And hypothetically, Alice’s theory will have the possibility of multiple finite or infinite realities. Furthermore, for Alice the possibility of infinite realities and subsequently possibility of infinite Universes is very real and true. Logically, Alice can argue that nature of reality itself is probabilistic, while for Jia, nature of reality is unique.

3.3 Nature of Reality

Based on this thought experiment, one can reason that nature of reality can be probabilistic (Alice’s reality) or it can be unique (Jia’s reality), depending on the information each had. Similarly, one can argue that if Alice was allowed to make further measurements and was allowed to acquire all information, her reality would have been unique. Alice’s inability to make measurements was decisive for the nature of reality for her to be one way or another. Using this premise, one can abstract this scenario to Humans ability or inability to make measurements. Humans are evolved to observe reality based on their five basic perceptions – sight, sound, touch, taste, smell. In addition, all the measurements humans make regardless of the field of study are based on or are extensions of these perceptions. In other words, human experience of reality is limited by his perceptions to make measurements. So, if there is some phenomenon of nature, which is independent of these perceptive mode of measurements, humans would be unable to observe or measure it. Subsequently, if this phenomenon is somehow linked with other observable phenomenon, probabilistic nature of the predictions is inevitable. Furthermore, for humans, nature of reality might seem probabilistic in this situation. A reasonable approach would be to suggest two types of nature of realities, “Absolute Nature of Reality” and “Observable Nature of reality”. An absolute nature of reality is the reality, governed by laws of nature, which are independent of

the measurements, with complete information and unique outcomes. On the contrary, observable nature of reality is governed by the observable laws of nature; is measurement dependent and outcomes can be unique or probabilistic. Humans' nature of reality is observable and is limited by their ability to make measurements. Furthermore, observable nature of reality can be probabilistic or unique depending on the information an observer has. If the information is complete, the observable nature of reality will be the absolute nature of reality with unique outcomes, otherwise it will be probabilistic with uncertainty.

4. Interpretation of Quantum Mechanics:

The nature of quantum mechanical theory is probabilistic, i.e. it makes prediction of outcomes using a probability distribution, rather than definite values. Furthermore, measurement process in quantum mechanics is arguably the most important aspect. On the foundation of probabilistic nature and importance of measurements, certain aspects of quantum mechanics can be qualitatively interpreted using theoretical consequences of "Observer's Dilemma".

4.1. Completeness of Quantum Mechanics:

The postulates of quantum mechanics are considered fundamental and the theory is considered complete and closed, taking into account that testing experiments lie in the domain of our currently acquired domain of physical and quantum mechanical experience[4, 5]. Conversely, some physicists argue the incompleteness of quantum mechanics, on the premise that it doesn't give a complete description for the physical system and is indetereministic in nature. To serve this purpose, hidden variable interpretations of quantum mechanics are suggested[1], which are deterministic in nature. However, one can qualitatively abstract the nature of Alice's theory and nature of quantum

mechanics as similar, based on the argument that both these theories are probabilistic with uncertainty. It has been argumentatively established that Alice's theory will be "Observably Complete". Furthermore, it has also been established that, human experience of reality is limited by his perception of making measurements. If one assumes, human measurements abilities have reached their limit as well as the ability to acquire further information, the implication of quantum mechanics being complete and closed from human's perspective stands true, or in other words, "Observably Complete". Furthermore, if one assumes quantum mechanics is "Observably Complete", the probabilistic solutions of the theory are allowed, and are true and real for humans. Consequently, the observable nature of reality being probabilistic is also permitted and real for humans.

Furthermore, it is the author's opinion, that argument of hidden variables or hidden information does seem valid in the current scheme of logic; for quantum mechanics to be an "Absolute Complete" theory, but nonetheless it is an "Observably Complete" theory. Furthermore, it is the author's opinion that the argument of quantum mechanics being an indetereministic theory seem rather immature, based on the premise of this paper. The foundations and nature of quantum mechanics as a theory is to give probabilistic solutions, and concept of unique determinism becomes void, for the theory. Unique determinism only applies to "Absolute Complete" theories, which as previously mentioned are also "Observable Complete", by basic logic. In addition, quantum description of reality is very real for human, such that it is "observable nature of reality", and is dependent on the measurement. However, based on the premise of this paper, it is the author's opinion that "Absolute nature of reality" is not quantum or probabilistic, and is independent of measurements or observation.

4.2 Everett Interpretation of Quantum Mechanics

Everett interpretation of quantum mechanics[6] suggests the possibility of infinite alternate realties, where all possible histories and futures are real. This interpretation stems from the solutions of the Schrodinger's equation of quantum mechanics. One of the theoretical consequences of Observer's Dilemma and Alice's Theory permits the possibility of finite or infinite realities. Furthermore, it has been argumentatively established that Alice's (Observably Complete) theory is qualitatively similar in nature to quantum mechanics. Therefore, it is the author's logical opinion that Everett interpretation of quantum mechanics abstracts perfectly with Alice's interpretation of infinite realities. Based on this premise, a strong argument would be to suggest that it is the nature of quantum mechanics theory to give probabilistic solutions and interpretation of these solutions can be the possibility to multiple realities. Logically, it has been established that all these multiple realities are true and real for humans, who experience "observable nature of reality". However, it is the author's opinion that "True Nature of Reality" doesn't have the multiple realities, rather it has unique reality.

5. Conclusion:

Based on the premise of this paper, it is the author's opinion that probabilistic nature of observable phenomena results from incomplete information. Theories can be developed from this incomplete information, and can still be successfully applied in the currently acquired human experience of reality. If humans are limited to acquire further information, the resulting theories will be "Observably Complete". Furthermore, the author is of the opinion that quantum mechanics is one such theory, and its fundamental postulates and nature, are to give probabilistic predictions. In

addition, incomplete information can indeed result in multiple realities and these realities are very real in the framework of "Observable Nature of Reality". Therefore, the author is of the view that quantum realities and the possibility of parallel realities can be argued to be real for the observer, in this case human's perceptive abilities. However, "Absolute Nature of Reality" is unique and distinct, independent of the measurement and observation and follows laws of "Absolute Complete" theories. On the contrary, quantum mechanics is limited by human's perceptive abilities to make measurements, but from humans' perspective it is complete. The author is also of the view that further information is still hidden in laws of nature beyond human perception, which hinders for quantum mechanics to be "Absolute Complete" theory. To understand "Absolute Nature of Reality", one should come up with innovative ideas not limited by ability to make measurements, directly or indirectly. Conversely, it is highly possible that humans by their currently acquired perceptive experience can never test these ideas experimentally and in that case one has to rely on the logical reasoning of unique predictions, as a source to decipher "Absolute Nature of Reality". Otherwise, the author argues that "Observable Nature of Reality" from human perception is very real and probabilistic nature of observable phenomena should be accepted.

References:

1. Bohm, David (1952). A Suggested Interpretation of the Quantum Theory in Terms of 'Hidden Variables' I. *Physical Review.* **85** (2): 166–179. Bibcode:1952PhRv...85..166B. doi:10.1103/PhysRev.85.166.

2. Ginsberg, Naomi S.; Garner, Sean R.; Hau, Lene Vestergaard (8 February 2007). Coherent control of optical information with matter wave dynamics. *Nature.* **445** (7128): 623–626. doi:10.1038/nature05493

3. Einstein, A; B Podolsky; N Rosen (1935-05-15). Can Quantum-Mechanical Description of Physical Reality be Considered Complete? *Physical Review.* **47** (10): 777–780. Bibcode:1935PhRv...47..777E. doi:10.1103/PhysRev.47.777

4. Max Born and Werner Heisenberg, "Quantum mechanics", proceedings of the Fifth Solvay Congress.

5. Bohr, N. (1935-10-13). Can Quantum-Mechanical Description of Physical Reality be Considered Complete? *Physical Review.* **48** (8): 696–702.

6. Everett, Hugh (1957). Relative State Formulation of Quantum Mechanics. *Reviews of Modern Physics.* **29** (3): 454–462. Bibcode:1957RvMP...29..454E. doi:10.1103/RevModPhys.29.454. Archived from the original on 2011-10-27. Retrieved 2011-10-24.

Acknowledgements:

The author would like to acknowledge the support of his parents, Dr. Naeem Akhtar and Jia. Furthermore, his siblings Dr. M. Haider, Shabina, Asma and Dr. Zunaira.