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Reconsideration of Classical and Quantum Physics Deterministically and Probabilistically: Nanophysicalism

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Abstract – This work focuses on resolving the origins of the probability theory and also reconsiders the classical and quantum physics both theoretically and experimentally in terms of deterministic and probabilistic processes. Primarily, the probability theory briefly re-examined in terms of its origins, validity and limitations. Additionally, classical physics and quantum physics are re-analysed both theoretically and experimentally in terms of deterministic and probabilistic mechanisms. Finally, philosophical argumentations are compared, combined and some important concluding remarks are briefly expressed. It is concluded that, unknown environmental effects and uncontrollability of that environmental effects, philosophically named as NanoPhysicalism, governs the probability theory, decisively influences some classical physical measurements and also the probabilistic structure of the quantum physics.

Keywords – Probability theory, determinism, quantum physics, classical physics, quantum philosophy, probability philosophy.

I. Introduction

Today's unbelievable scientific achievements and ultimate smart technologies in addition to comprehension of life, nature and human structure are all based on scientific and philosophical efforts achieved over the centuries [1]. In this sense, philosophically deterministic and probabilistic structure of the nature have been an important topic of the sciences and philosophy [2,3]. Especially probabilistic structure of the quantum theory has been attracting even more interests to the probabilistic and deterministic processes within sciences and the debate has a long way to be concluded decisively [4-8]. Therefore, it is quite legitimate to reconsider and try to resolve the origins and the limitations of probabilistic and deterministic processes within the classical and quantum physics.

The origin of the stochastic or random phenomena has been a challenging topic of sciences and philosophy. Probability theory, due to its subtle structure, has a number of well-recognised interpretations, namely; classical [9], logical [10], subjectivist [11,12], frequentist [13], propensity [14] and best-system interpretations [15], all focus to resolve the origins, meanings and limitations of the theory. Noticeably, De Finetti offered that probabilities are subjective and none of the objective interpretations of the probability make sense [12], and this approach is later re-handled and formulised to some extend [16]. Alternatively, the constructor theory of information is recently proposed and the origin of the probability theory is basically attributed to so-called *super information* theories which are non-probabilistic and conforming to certain constructor-theoretic conditions [17]. It is also proved that the unpredictability of quantum measurement outcomes, to which constructor theory gives an exact meaning, necessarily arises in *super information theories* [18].

Scientific activities obviously can methodologically be divided into two separate sections, namely theoretical and experimental studies [19]. Theoretical efforts are purely productions of human thoughts or consciousness and tries to mathematically model the natural phenomena mostly in an idealised world by means of the mathematical equations. The experimental studies, on the other hand, are based on experimentations or measurements achieved by means of various measurement tools, techniques and approaches within the real world. Natural processes ought to also be considered distinctly for the macroscopic and atomic structures, in the sense that the physical processes seem to be greatly different. Hence, in order to acquire a complete picture and comprehension of the probability phenomena, the probability theory, to our view, ought to individually be re-examined in terms of macroscopic and atomic scales and also in terms of experimental and theoretical considerations. Determinism should also be carefully re-examined in terms of idealised/theoretical world and real/experimental world at both macroscopic and atomic scales [20-22].

The present state of the sciences considers that the theoretical formulations relating to macroscopic phenomena is surely deterministic, which means in an idealised world, by using the relevant mathematical equation one can predict the outcomes of any specific phenomena with an infinite accuracy [21,22]. Classical physics, governing the macroscopic phenomena, is assumed to be purely deterministic on the theoretical basis [23]. However, there seems to be some problems with the experimental side of the classical physics, in the sense that, if one uses highly sensitive measuring devices then every single measurement basically leads to a slightly different result [24]. Increasing the sensitivity of the measuring device increases the deviations of the outcomes. Therefore, the experimental scientists always express the experimental errors for the measurements [25]. This situation is actually interesting in a way and to some extend indicates to similarities with the cases within the probability theory. Therefore, this deserves a deeper and closer philosophical analysis which is partially within the scope of the present work [26]. The atomic world is, on the other hand, known to be governed by the quantum physical processes. Quantum physics, as it stands, seem to be even more interesting in the sense that theoretically it is considered to be containing both deterministic and probabilistic processes [7, 27]. This obviously does not match with the classical physics. The measurements within the quantum theory face exceedingly interesting results and demonstrate probabilistic character and many counterintuitive results, therefore quantum measurement concept ought to be reconsidered and resolved in terms of probabilistic and deterministic points of views [11].

The present work initially deals with the origins of the probability theory and briefly re-examines it in terms of validity and limitations, eventually linked to the measurement problem. Following that, the classical physics is reanalysed in terms of the theoretical and experimental efforts and also in terms of deterministic and probabilistic mechanisms. Finally, the quantum theory is re-questioned in terms of its origins, its probabilistic and deterministic aspects both theoretically and experimentally. Conclusively, the philosophical discussions compared, combined and important consequences are underlined and significant concluding remarks are briefly expressed.

II. Problem Statements

The present effort proposes to evidently answer the following fundamental problem statements concerning the probability theory and also the probabilistic and deterministic structures of the classical and quantum physics.

1. What are the origins and limitations of the probability theory?
2. What are the effects of deterministic and probabilistic processes within the experimental and theoretical approaches concerning the classical physics?
3. What are the effects of probabilistic and deterministic processes within the theoretical and experimental approaches concerning the quantum physics?
4. Is it possible to combine probabilistic processes within the macroscopic and the atomic worlds, if so how?

III. Reconsideration Of The Probability Theory

Probability theory is, in fact, founded to analyse games of chance in the 16th century and almost completed in the 19th century. Probability theory initially dealt with only discrete variables such as tossing a coin, rolling a dice or picking a game card. These phenomena are traditionally considered as random which means that the outcome of a specific event cannot be predicted before it occurs [10]. The outcomes are assumed to be determined solely by chance. The possible outcomes of these events are all discrete, for instance two possible outcomes exist for the coin which are head or tail, similarly dice has six possible outcomes which are 1, 2, 3, 4, 5 and 6. The fundamental ingredient of the probability theory is based on an experiment that can be repeated, at least hypothetically, under essentially identical conditions and may lead to different outcomes on different trials. Probability is basically defined as the total possible number of desired outcomes divided by the sample space which means the number of overall possible outcomes. The probability, by definition, is always a number between 0 and 1 with infinite possibility. If the desired outcome is head, for instance concerning the tossing a coin experiment, then the probability is obviously ½.

In order to understand and resolve the tossing coin experiment in more detail, a deeper analysis is certainly needed. The first point is that, before tossing the coin, the two possible outcomes of head and tail are potentially present on the coin. Tossing the coin, in fact, means performing the actual experiment or doing the actual measurement and complete motion of the coin is undoubtedly governed by the gravitational laws and kinematics equations of physics [28]. Hypothetically, if we knew and were able to control all the influencing parameters, such as initial velocity, initial angle, pressure, air friction, temperature, gravitational acceleration, with infinite precision then the specific outcome would surely be predictable without any experimental error. In that case, the event would not be a chance game, and would rather be a deterministic phenomenon. As an overview, tossing coin experiment, under the illuminations of the approach above, has some important specifications ought to be underlined; 1-Entire event is governed by the physical/natural laws. 2-Possible outcomes are discrete. (head or tail) 3-Possible outcomes are decidedly close to each other. 4-Possible outcomes are extremely sensitive to environmental effects. This basic approach essentially demonstrates that the actual probability arises from firstly the *lack of knowledge* that determines the outcome and secondly the *inability of controlling the parameters.* This argumentation of unknown and uncontrollable processes indicates the approach of super information theories [17,24]. The problem, at this point, is that it seems impossible to set fully identical experimental conditions. Supposedly, performing the same experiment many times in completely identical conditions is possible, however physically and realistically speaking it seems impossible. Hence, it is quite logical to assume that the stochastic or random processes essentially originate from some uncontrollable and unknown parameters that influence and determine the outcomes. The same reasoning can surely be used for rolling a dice, picking a card, predicting the weather or predicting the outcome of a specific polling station. The outcomes of all these examples cannot possibly be predicted due simply to firstly the lack of information on the parameters that determine the specific outcome and secondly due to the impossibility of controlling the parameters effecting the outcomes [24].

The other important point ought to be made, at this point, is that the probabilities for each specific outcome, head or tail for the coin experiment, potentially and simultaneously exists before the actual experiment performed. At the end of the experiment though, the resulting outcome only exists and the other probabilities simultaneously disappear. This processes principally and exactly happens in quantum physics. Additionally, it is obvious that the outcomes are decidedly close to each other and extremely sensitive to environmental effects. The environmental influences appear very important because it means that any tiny change in the environmental conditions would conclude completely different outcomes. These arguments can surely be adopted to all probabilistic events without any exception, such as, picking a specific ball from a closed box, predicting the outcomes of a specific election, predicting the outcome of a dice rolling.

Generally speaking, any measurement process is managed by the interactions of three distinct concepts, namely 1. measuring person or mind, 2. measuring tool or device and 3. measured concept. This basic analysis can surely be compared with the tossing coin experiment and it simply leads to an interesting result. Concerning the coin experiment, the measuring person tosses the dice, measurement device is the dice and the measured concept is the actual outcome. Reconsideration of the coin experiment and re-examination of the measurement activity leads to a different position. The measurement, in this specific probabilistic random event, seems to be involving not three but rather four components, namely, 1. Measuring person or mind, 2. Measurement device or tool, 3. Measured concept; and additionally, 4. The interaction between the actual measurement and uncontrollable and unknown environmental influences. The interaction between the measurement process and the environmental effects can be expressed in details. Specifically, the probabilistic structure of the outcomes is decisively determined by these factors; firstly, possible outcomes are discrete (head or tail), secondly possible outcomes are decidedly close to each other and thirdly possible outcomes are extremely sensitive to environmental effects. Tossing a coin, for example, is very highly environment sensitive and predominantly determined by the uncontrollable and unknown environmental influences. Similar arguments can be given for other probabilistic phenomena no matter if it is natural or social event. As a conclusion, under the lights of the argumentations summarised, clear answer to the first problem statement, that is the origin of the probabilistic phenomena/event, can be expressed as firstly *unknown environmental effects* and secondly *inability to control the environmental effects*. The present approach is in harmony with recently proposed constructer theory of probability which is based on similar arguments known as *super information* processes [17,18].

IV. Reconsideration Of Determinism And Probability In Classical Physics

Classical physics deals with and tries to resolve any natural macroscopic phenomena, containing primarily energy or mass, within the space and time. Nature and natural phenomena is studied by two distinct means, namely experimentally by measurements and theoretically by mathematical equations. Theoretical efforts are carried out within the idealised world and mathematically model the natural phenomena. Experimental efforts, on the other hand, are carried out in real conditions and surely subject to many environmental influences. Therefore, philosophical argumentations ought to be carried out separately for theoretical and experimental works. Determinism basically means that the outcome of any specific event can certainly be predicted without any errors. This basic description, at first sight, seems to be working exceptionally well for the classical physics and therefore the classical physics is traditionally considered and accepted to be purely deterministic [22]. However, this philosophical thesis could surely be questioned deeper, knowing that quantum physics, as the physics of atomic structures, is not deterministic but rather probabilistic. Hence, philosophically re-examination of the classical physics both experimentally and theoretically seem to be legitimate to explore further under the illuminations of the recent developments in both sciences and philosophy [21].

Theoretical physics seems to be fitting to the deterministic philosophy quite well, in the sense that, whatever the actual physical size, theoretical outcomes of any natural phenomena can be predicted certainly, even for infinitely small sensitivities [29]. The results of mathematical calculations within the limits of the considered system are certain and contain no errors, philosophically leading to solid determinism.

In order to re-examine the experimental classical physics, a simple and straightforward experiment is basically considered. What happens when a classical experiment, for instance a free fall experiment, is performed 1000 times with as much as the same physical conditions? Is it possible to get the identical results for the flight time? This a very fundamental experimental question and it is clearly known that identical results are never obtained. Therefore, the experimental classical physics surely contains many philosophical questions within [28]. In the experimental physics, any measurement in a real world, as previously expressed, involves at least three components, namely measuring person, measuring device and measured concept. The measurements are realised within the real world, influenced by instantaneous environmental effects and therefore always the subject of some degree of experimental errors [25]. The measurement errors essentially could be coming from all components. Firstly, the measuring person as a conscious mind, can be effecting the results by some amount, however it is thought to be negligible at least for the measurements at macroscopic scales. Secondly, the errors may be arising from the actual measuring device, in relation with the sensitivity of the device. *Sensitivity* or precision of the device is defined as the half of the minimum measuring interval of the scale. In order to manage a meaningful and accurate measurement, the sensitivity of the device must be much smaller than the measured concept. Additionally, *error rate* of a specific measurement means how accurate a measurement is achieved and error rate is defined as the sensitivity of the measuring device divided by the actual measurement value. For instance, if one measures a length of 10 micrometres with a device sensitivity of 1 micro meter the error rate is % 10, however if one measures 1mm with the same device sensitivity the error rate reduces to % 0,1. The ultimate aim is essentially to measure the theoretical results and to do so, experimental scientists try to use the devices with lowest sensitivity to decrease the error rate. However, it is a fact that the experimental outcomes do not normally match the theoretical results and some amount of experimental error always exists [30]. Assuming classical macroscopic world, some of the experimental errors are assumed to be originating from the sensitivity of the device. Obviously by definition sensitivity of the device determines the error rate of the measurement and as one decreases the sensitivity, the experimental absolute error also decreases. The influence of the measuring device can in fact be improved by using more sophisticated devices with lower sensitivities, but to what level? The other very important factor that could be effecting the outcome of a classical physics measurement, is unavoidable instantaneous environmental effects. This view seems to be neglected so far considering the philosophical implications. It is quite clear that *unknown and uncontrollable environmental effects* could be neglected for large scale measurements, nevertheless might really be dominant and decisive especially for very tiny measurements. Therefore, one may think that even though the classical physics is traditionally considered to be deterministic, the experimental side of the classical physics seem to be problematic [30].

At this point, it would be very beneficial to reconsider the flipping coin experiment. The case can be considered as a pure classical physics experiment and interestingly also as a classical probability problem. It is well known that the outcome of a specific throw cannot definitively be estimated. Therefore, the event is considered as a pure probability problem, and the probability of heads is equal to the probability of tails with the probability of ½. If, on the other hand, the experiment can be resolved in terms of classical physical laws and it is clear that the specific outcome of any throw is influenced by the gravity and also various effects such as initial velocity, initial angle, air friction, temperature, air pressure and the height. If it was possible to know and also control all these parameters that affect the outcome, then the specific outcome would be estimated in advance. However unfortunately it is not possible to know all these environmental factors. Therefore, the outcomes cannot be predicted and it is obvious that any tiny change in the environmental conditions effects can easily affect the specific outcome, because two possible results are very closely linked to each other (outcome sensitive case). The probability theory comes in, at this stage, and gives the estimation by only percentages. It is very central to understand and underline the origin of the probability theory, that seems to be the lack of knowledge and uncontrollable environmental effects as previously concluded [30]. In other words, the outcome of any specific event is determined by purely the interaction of the system with the environment and the magnitude of the influence on the specific outcome depends on the experiment and the actual experimental setup.

As a result, under these illuminations of these considerations and argumentations, one can conclude that classical physics is *theoretically deterministic* however experimentally the outcomes are influenced by *uncontrollable and unknown environmental factors* hence is *non-deterministic* that speculatively could be *probabilistic* at very small scales [2].

V. RECONSIDERATION OF PROBABILITY AND DETERMINISM IN QUANTUM PHYSICS

Quantum physics comprehensively resolve and predict the natural phenomena at atomic and subatomic scales. One of the four crucial postulates, on which the theory is built, is the de Broglie's wave particle duality. According to the wave particle duality, any particle in atomic world is accompanied by a wave and all the physical properties of that particle is determined by this wave function. The wave function is obtained by the solution of the Schrödinger wave equation and the wave function is simply a mathematical function, described in terms of space and time and philosophically deterministic in character [28]. In other words, the wave function provides the exact wave shape at a time of t and a position of x, in one dimension. There is no probabilistic structure whatsoever concerning the actual wave function.

The fundamental problem with the wave function is that, the wave function spreads in space and time identical to the classical waves however represents only a single whole particle. In this sense, it is quite demanding to understand and visualise the case physically and also philosophically. The other important point is that, the theoretically calculated wave function is not a measurable concept. In other words, it is impossible to measure the wave function accompanying a single particle that continuously moves in space and time. In order to overcome these problematic situations and actually to get a connection between the theory and the real world or physical reality, famous physicist Born's interpretation and description comes forward. Born expressed that the actual wave function is not measurable concept and therefore has no physical meaning, however the absolute squared wave function should have a physical meaning and that is defined as the *probability density* [28]. This is the point, the probability concept comes into the quantum theory and dominates the entire theory. The squared wave function simply gives the finding probability of the particle per unit volume in three dimensions. Vitally, the physical connection of the theory to the real world is maintained by means of this basic definition. Born's interpretation of the wave function and definition of the probability density simply transforms the theory from deterministic to the probabilistic [31]. Thus, the quantum theory basically is not able to predict the outcome of any specific measurement and only suggests probability measures for certain problem cases. Classical mechanics, on the other hand, theoretically and perfectly predicts the outcome of any specific experiment at macro scales and therefore the theory is considered to be perfectly deterministic as discussed previously. This fundamental difference philosophically separates the classical mechanics from the quantum mechanics.

The probabilistic structure of the quantum mechanics ought to also be tackled theoretically and experimentally, similar to classical physics. Theoretically speaking, the theory, to some extent, that is the actual Schrödinger wave equation and the wave functions are surely deterministic. The rest of the theory, based on the wave functions is completely probabilistic [8]. Quantum theory cannot simply predict for instance the position of an electron at a specific time and cannot predict the outcome of any specific measurement. However, realistically speaking this does not mean that the electron has not a definite and measurable specific position at a specific time. Ontologically, any atomic particle must continuously exist and at a point of x and at a specific time of t. This actually means that there must be a deterministic theory but we are unfortunately unaware of that. There have been, in fact, some serious efforts to develop a deterministic quantum theory however the attempts have been unsuccessful [32]. The experimental side of the quantum theory also arises some problems similar to the theoretical ones. The outcome of any measurement cannot be predicted before the actual measurement, a good example is the famous experiment of Schrödinger's cat. The fundamental question is that, what mechanism or mechanisms influence and determine the outcome of a specific quantum experiment or measurement? The most respectful and successful approach to this problem is given by Zurek [33]. Zurek and his colleagues offered that the outcome of a specific quantum measurement is governed by the *environmental natural selection* or so called *quantum Darwinism*. This approach essentially accepts the probabilistic structure of the experimentation or measurement in harmony with the theory and vitally indicates the influence of some unknown and uncontrollable environmental effects.

Combining the arguments and discussions presented previously, concerning the probability theory and also the classical physics, it seems quite legitimate to think and assume that quantum theory and measurement are philosophically probabilistic due to the same reasons, namely *unknown and uncontrollable environmental effects*. The former reason, in other words, unknown environmental effects can set the roots of a deterministic theory which is not founded yet. The latter reason, uncontrollable environmental effects, are more difficult to deal with, in the sense that the classical mechanics has also same problematic situation. The uncontrollable environmental effects seem to be the common reason underlying the probabilistic structure of the quantum theory and the measurement problem of the classical mechanics. The very reason of obtaining slightly different results of for the same classical systems seems to be working for the quantum theory, that is the *system-environment interactions* or the *lack of knowledge*. The philosophy of the discussions, relating to the origin of the probability concept, seems to be fitting to the philosophy of *physicalism* but furtherly to *NanoPhysicalism* [34]. NanoPhysicalism, as a philosophical thesis, can basically be described as *unknown and uncontrollable system-environment interactions* governed by the physical laws at nano-scales. This approach is in synchronisation with the constructer theory of probability which is based on super information processes [17,18]. The suggested approach is also in agreement with the previously proposed approach that the probability, as given by the Born rule, and emerges as a consequence of insufficient knowledge of the observers [35].

VI. CONCLUDING REMARKS

Under the illuminations of the approaches and argumentations given above, following concluding remarks can be expressed to clarify the answers of problem statements which are proposed to be answered genuinely in the present work.

1.The probability theory originates from firstly *unknown* environmental effects and secondly *uncontrollability* of that environmental effects. No matter whether it is a chance game, whether a weather prediction or a continuous probability function in classical physics, the processes are all governed by the natural laws however the outcomes are too complicated to theoretically execute [18, 35].

2.The classical physics is surely *deterministic* in terms of the theory, however experimentally it seems *non deterministic* since every single measurement in fact gives a slightly different outcome even though the measurement conditions are set to be the same. The non-deterministic structure seems to be arising again unknown and uncontrollable environmental influences, similar to the probability theory [18, 35]. Measurements with lower sensitivity are especially dominated by the environmental effects however increasing the sensitivity reduces the environmental influences that could be negligible.

3.The quantum mechanics theoretically contains both deterministic and probabilistic processes, however experimentally the theory is purely *probabilistic*. The outcome of any specific event/measurement cannot be predicted by the actual theory and the outcome of any measurement ought to be influenced by the instantaneous interaction between the measured system/concept and the environmental effects which must be governed by the natural laws. The environmental influences are unknown and indeed uncontrollable, similar to the stochastic structure or randomness of the probability theory and also similar to the experimentation in classical physics [18, 35].

4.In order to answer the fourth problem statement, it seems straightforward to combine the arguments and discussions presented and it appears reasonably clear that *unknown environmental effects* and *uncontrollability of that environmental effects* governs the probability theory, experimental classical physics, probabilistic structure of the theoretical and experimental quantum physics [18, 35].

As a conclusion, all these uncontrollable and unknown environmental effects can philosophically be combined and named as *NanoPhysicalism.* NanoPhysicalism, as a philosophical thesis, means that the outcomes of a phenomena are decisively influenced by unknown and uncontrollable environmental effects governed by the physical laws at nano-scales, initialized in order to construct the quantum information field theory of the brain-based consciousness [34]. In this sense, there seems to be much work ahead to be carried out in order to reach satisfying and decisive conclusions.

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