Research Essay

Heisenberg Uncertainty Principle & Kant Philosophy: Why Hawking Thinks Philosophy Is Dead

Hossien Hossieni[*1], J. M. A. Fatah[1], Saed Kaki[2] & Arman Khalil[1]

[1]University of Sulaimani, School of Science, Department of Physics, Sulaimani, Kurdistan-Region
[2]Unversity of Salahaddin, College of Arts, Department of Philosophy, Erbil, Kurdistan-Region

Abstract

In this study, we explain why Hawking thinks in his book (The Grand Design) that philosophy is dead. For this purpose, in the second and third sections we first introduce in brief quantum mechanics, Heisenberg uncertainty, Bohr Complementary and path integral approach to quantum mechanics and explain Young Experiment as heart of quantum mechanics and why no one can predicate future a microscopic system definitely. In fourth section, we explain Kant philosophy about causality and Kant understanding for phenomena and things itself. We discuss towards the end of this work the Copenhagen interpretation, philosophy and Kantian concepts which cannot be used to interpret reality of phenomena on atomic level and quantum mechanics. We then introduce the alternative of philosophy in modern physics, i.e., mathematics.

Keywords: Hawking, Grand Design, philosophy, Copenhagen interpretation, Kant philosophy, Heisenberg uncertainty, phenomena, Noumenon, complementary, mathematics**,** quantum mechanics.

1. Introduction

Hawking in his book the Grand design asks “How can we understand the world in which we find ourselves? How does the universe behave? What is the nature of reality? Where did all this come from? Did the universe need a creator?” and he states “Traditionally these are questions for philosophy, but philosophy is dead. Philosophy has not kept up with modern developments in science, particularly physics”[1]. Philosophers were alarmed when they heard the phrase “philosophy is dead” [2]. Maybe the word “dead” is a challenging word and the objections are attributed to that. The tool of philosophy to interpret phenomena is language [3]. Physicists assert, in quantum mechanics (QM), the imprecise nature of human language to describe different phenomena [4][5]. QM has undoubtedly, managed to change our knowledge and our outlook on the world and different phenomena in physics.

* Correspondence: Hossien Hossieni, PhD, University of Sulaimani, School of Science, Department of Physics, Sulaimani, Kurdistan-Region. Email: hossieni@univsul.edu.iq

The influence of QM on philosophy has created challenges for philosophers to seek answer to the most important questions in humans thinking. Natural sciences aid philosophers in creating their arguments while scientists use philosophy to tie logically those phenomena together [6]. In the first few years of twentieth century QM appeared on the science. it made different philosophical views among physicists. The physics community was divided into two schools of thought, the pro- quantum one led by Niels Bohr while Albert Einstein was in the forefront of the opponent school. Einstein and his followers believed in classical deterministic of scientific predictions and they were uncomfortable with the Copenhagen interpretation of QM predications [7]. To them, QM is an incomplete theory and they tried to find an alternative theory with hidden variables that coincides with the Laplace scientific determinism. The philosophy behind which is the classical physics concepts, “I am convinced God does not play dice” is a famous declaration to show his unease with the theory of QM [8].

In classical philosophy there was a contention between philosophers on rationalism and empiricism. Rationalists claimed that there are some significant ways to obtain our knowledge and our concepts are independent of our senses. On the other hand, the empiricists believed that we acquire all our knowledge via our senses [9]. Kant used classical physics to establish a thought system which is known nowadays as Kant philosophy. One of the most important category in philosophy is the causality principle. This category has been a controversial one in the history of philosophy. Kant considered causality as priori, which implies that it is independent of experience [10].

In QM, causality is no longer a valid concept and this has created a big challenge for the deterministic physicists and philosophers who believed Kant’s argument. In this paper, we first explain some aspects of both quantum mechanics and Kant philosophy. It will be shown that the roots of Hawking’s expressions go back to discussions of great physicists in the dawn of quantum mechanics and the Copenhagen interpretation.

2. Quantum mechanics and Heisenberg uncertainty

Towards the end of the nineteenth century, some physicists thought that all the laws governing nature have been discovered and what is remained is to make them more precise [11].

Some experiments in either microscopic level and/or high speed worlds showed that classical physics is an incomplete theory.

This necessitated searching in earnest for a solution. QM was one of the theories which addressed and solved main problems in classical physics and it was a revolution in science which started by the original works of Plank, Einstein, Rutherford, Bohr, and Born. As a direct result of the works done by Schrodinger, Heisenberg, Dirac, and Pauli, QM reached its peak. Schrodinger and Heisenberg presented a “complete” quantum theory that offered a full explanation for all phenomena in microscopic world [12]. This theory describes the interaction between matter and electromagnetic radiation. In QM, the energy states in a bound system are quantized and one can only talk about probabilities with regard to future of the system. Every system can be described by a wave function which represents its energy states. Each state corresponds to an Eigen value which can be measured experimentally [13]. Wave functions do not correspond to any physical quantity in real world as they are just mathematical tools [14].

According to Max Born interpretation, the square of a wave function for a system gives the probability of finding that system in a specific state [15]. Werner Heisenberg laid the basis of QM by discovering, in 1927, what is known as the Heisenberg uncertainty principle. In terms of this principle, the more precise one measures the position of a particle the less precise will be the measurement of its momentum and vice versa. Momentum is the product of mass and velocity; this implies that knowing a particle’s property well enough will lead vagueness about the other property. Similar to these two properties, time and energy are tied together by the above principle.

When you measure energy of a system with precision, you consequently will lose preciseness in time of the measurement [16]. Schrodinger and Heisenberg independent approaches to quantum mechanics have been proved that they are equivalent and indeed the wave mechanics of Schrodinger and the matrix mechanics of Heisenberg are complementary. In term of Bohr’s complementary principle the wave and the particle properties of a system or the visual and causal representations both complement each other [17]. This implies that when we conduct an experiment, we cannot simultaneously observe both particle and wave properties of an object. These two properties are separate and it is up to the observer to choose which one to look at. According to the uncertainty principle, one cannot predict the state of a system with any precision as the observer interferes unavoidably with it. This is a failure for causality principle [18].

3. Feynman path integral and Young experiment

In 1940s Richard Feynman presented a new version of QM that depends on classical principle of least action. As a matter of fact, Paul Dirac mentioned this principle in his book [19]. In classical mechanics there is just one path for an object to move on but in QM all paths are possible and each of which plays its role. One has to consider the sum of all of these paths when it comes to calculate the transition amplitude. Each path is indicated by a number and the sum of all these numbers constitute the most probable path. The numbers of all those paths which are inconsistent with Newton’s law of motion will cancel each out. If one lets Plank constant, h, to approach zero then the result approaches that of classical one. This constant differentiates microscopic world from the macroscopic one [19]. Figure 1 shows a space-time plane with the initial point (x_1,t_1) and the final point (x_N, t_N) of motion of a particle. There are infinite paths between the two points and all of them are possible in QM [20].

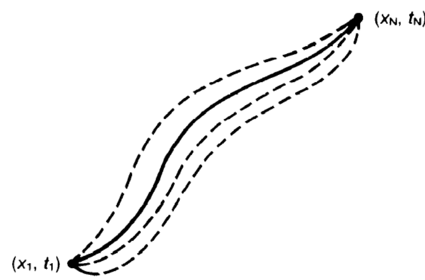

Figure 1: The possible paths for a particle to move from an initial point to a final point in QM is infinite but when ($h \rightarrow 0$) then the classical paths prevails.

One of the stunning experiments in physics is the Young experiment shown in Figure 2. It consists of a photon source (or another particle), a double slit plate and a screen on which interference patterns can be seen. In this experiment, a coherent beam of photons is divided by a double slit screen into two coherent beams and they interfere with each other after passing through the slits to make dark and bright points on the screen. This experiment can be done by a single photon. Either a photon passes through both slits at the same time or no one can say for certain through which slit the photon did pass. There are infinite paths that the photon can take from the initial to the final point and each of these has a probability. But when an observer uses a detector to find out the slit the photon passed through then this will cause the disappearance of all the interference fringes. The Young experiment shows the wave properties of a particle and if we want to know the particle passed through which slit, this means measuring the particle property of a quantum entity, then this causes the disappearance of the interference fringes[1][21]

Figure 2: Young experiment with path integral explanation.

4. Kant's understanding of causality

One of the basic problems of philosophy that many philosophers have historically thought about is the causality principle. Most ancient and middle century philosophers took a view that cause is behind every phenomenon. In ancient Greece, Aristotle believed that *cause* involved four features. Generally, in Greek philosophy the cause of phenomena has roots in nature only [22].

4.1 Kant and Judgments

To understand causality principle, it is necessary to understand propositions. Prior to Kant, David Hume believed that logical researches depend not only on the difference in logic (i.e., logical separation) but also the definition of the statement [23]. Logical separation involves metaphysical statements and is not empirical or analytical. To put it in another way, the propositions cannot be verified or rejected by experiments or observations and they are not falsifiable. For instance, propositions like: "Himalaya mount is white" or "salt dissolves in water" are empirical and analytical while challenging statements such as "rain is wet" or "if Socrates is human and human must die then Socrates die". But statements like "human is an ethical being" and "there is God" are meaningless.

Kant did not challenge this as everyone agreed with the above So a meaningful proposition is a one that is either empirical or analytical [24]. Once this separation is agreed upon then the conclusion is that metaphysical propositions are meaningless. One should remember that the Kant's division is not related to the proposition but to the judgments, i.e., those propositions that were judged and proved. The Kant's approach to a proposition like "cat is an carnivorous animal" is how to judge it. In Kant philosophy every judgment is either analytical or synthetic. This judgment is a relation between a subject and its predicate that is discussed rationally. This relationship is accessible in two ways: predicate (B) is related to subject (A) seems consistent with the idea of (A) or (B) to be totally outside the idea of A although they are related. The first is an analytical judgment while the second is a synthetic one.

A judgment of the kind saying *raining is humidity*, the predicate *humidity* is consistent with the subject *raining*. Putting it differently, a statement like "*raining is not humidity"* makes an inconsistent judgment. But in a judgment like *raining is cold*, the predicate of *cold* is consistent with *raining*, in other words, a judgment raining *is not cold* does not make any inconsistency [25]. The first proposition is analytical while the second is synthetic. Analytical propositions clarify the r meaning aspects of the proposition. From Kant's view, every judgment is either a priori or a posteriori. A judgment is a priori only and only if it does not rely on any sense impressions. Kant's classification produces these four categories:

- Synthetic of a posteriori
- Synthetic of a priori

- Analytical a posteriori
- Analytical a priori

As the fourth judgment is inconsistent then we have to ignore it. Analytical proposition is dependent on the meaning of the word but it does not give us any new and definite information. On the other hand, a posteriori proposition depends on experience and so it remains only three types of judgments. Kant believed not only there are these judgments but also there are many examples r of them in our minds [26]. It is necessary that all analytical judgment to be a priori. Consequently, these types of judgments are logically independent of sensory. Every analytical judgment must be a posteriori and every a priori judgment must be none analytical or synthetic.

Now consider this judgment, *every change has a cause* which is a priori as it is not necessary to apply a proposition to explain sense impressions. At the same time this judgment is a synthetic one. For instance, if one thinks that a change occurs without a cause, as in the case of frequent sense impressions. Of course, according to our interpretation, there is no contradiction here. Contrary to this, if we reject the idea of a change to have a cause then one might ask this question: are we allowed to collect information from the nature? Kant's answer to this is a definite no [27]. Kant's philosophy is opposite to the Hume opinions on cause and effect.

Hume emphasized that there no relationship between cause and effect. According to Hume, it is just a matter of habit that we, humans, relate cause to effect based on observation. Hume totally disagrees with this relationship and goes even a step further by discarding the metaphysical aspects of the existence. But Kant opposed Hume's opinion and believed that the origin of causality is not from the nature but is pre-empiric. The judgments are duties of mind, understanding, and are pre-empirical. According to Kant's philosophical categories, causality is not a type of idea that comes from outside. Kant thinks that abstraction of causality is via logical form and conditional proposition [28]. For instance, when we say that every change comes from a cause then this is a priori synthetic judgment. This implies the creation of the concept of causality is in understanding. Therefore, understanding via this judgment, is understanding the concept of causality.

4.2 Noumenon and phenomenon

In order to protect his philosophy from idealism, Hume's simple phenomenalism, and criticisms against both Berkeley and Hume, Kant had to make a difference between phenomenon and noumenon. Phenomenon from philosophical point of view depends on priori form of sense, time, position and understanding categories. We have to believe in noumenon in addition to phenomenon. In reality, noumenon determines the boundaries of our knowledge. Therefore, from theoretical perception, a noumenon has both negative and positive sides and belongs to the practical wisdom part of in Kant's philosophy.

Dogmatic philosophers have not set a boundary to human wisdom and they believe that some subjects similar to noumena are accessible. Kant, having agreed with them, set a part in the understanding section for purely priori, such as causality and substance. The point is that in Kant opinion these categories lose their contents when they are beyond sense boundaries. The understanding categories become objective when they originate from perceptional subjects. In Kant's opinion there is a difference between thing-in-itself and noumenon. Thing-in-it self's origin is unknown while for Noumena's concept, there is a rational world which is independent of any experience [29].

5. Discussion

Quantum mechanics is a branch of theoretical physics that deals with understanding of the properties of smallest physical objects which consist of atoms and subatomic particles. The theories that are concerned with these subjects are odd as the famous theoretician Richard Feynman once said "I can safely say that nobody understands the Quantum mechanics" [30]. Atoms and other subatomic particles are not similar to classical macro objects as we can only see their effects. Data gathering from quantum experiments and their theoretical explanations are two different kettles of fish [31]. In term of Copenhagen interpretation, a quantum mechanical system can be described by a wave function (ψ). This wave function represents human knowledge of the system. The interpretation of the system is intrinsically probabilistic. The probability of an event to occur has shown to be the square of the wave function.

In terms of Heisenberg uncertainty principle, all properties of a system cannot be measured at same time. Furthermore, the complementary principle states that the duality of wave-particle is a basic characteristic of the matter. It is worth noting that the tools we use, which are classical by nature, to measure properties of a quantum system are only capable of recording classical measurements. Another aspect of the Copenhagen interpretation is the correspondence principle which states that the description of a large quantum mechanical system should be approximately agree with that of a classical one [32]. According to the Copenhagen interpretation, a wave function is not a physical reality but is an abstract concept. The wave function, in this view, is just an abstract mathematical apparatus to calculate a probability for an event. Putting this differently, this interpretation states that a wave function contains all possible outcomes for an event to occur, but as an outcome becomes a certainty then all other outcomes will be cancelled [14].

Heisenberg uncertainty principle governs quantum mechanics. Most of things cannot be seen nor sensed in the microscopic world. One can only know things with certain probability. This makes quantum world blurry.

Scientific predictions on events in nature are statistical and are stated through probabilities. We cannot determine the position of a particle exactly. It is only with increasing probability we can estimate where the particle is. We cannot ever measure both position and momentum simultaneously and hence this blurriness in quantum mechanics cannot be eliminated. Therefore, there are no hidden variables to find or to try to resolve this limitation [33].

When daily languages with classical concepts, which are in macroscopic world, are applied to microscopic world will lose their accuracy. Niels Bohr believed that our concepts are not pure but they are limited and we have to use these limited concepts to understand the nature [6]. As we mentioned earlier, the causality principle in quantum mechanics fails but the philosophers that deal with the new Kantian philosophy believe that Kantian interpretation of causality is correct and as a result the contradiction between Kant philosophy and Quantum mechanics implies that quantum mechanics is incomplete [6]. According to the Kant Philosophy, causality is not an empirical assertion but is a category of the understanding, known as, a priori and on which all other experiences depend. This law should be correct because if it fails then we cannot objectify our observations and we must accept the existence of a relation between cause and effect.

However, if causality fails then it creates challenges for the repeatability of science and that the natural sciences include only the objective experiences therefore, science must accept causality and without this law there is no science. Causality is a mental tool that we use to integrate our senses into our understanding. Therefore, from Kant’s view quantum mechanics or any other branch of science cannot break this law. As Kantian philosophers think new physics is in mistake if scientists cannot find causes for effects. This implies that their information is incomplete and they must search more to find causes for quantum mechanical events [6]. But in the view of Copenhagen interpretation our quantum mechanics is complete and it is not necessary to search more to find causes for effects. Take Young experiment in Fig. 2 as an example. Here, we cannot know photon (or electron) passes through which slit and if we try to know the particle’s trail then the interference pattern disappears. There are a huge number of examples in quantum mechanics that are somehow related to the Young experiment and show more search does not mean obtaining more information about causes for effects [1]. Consequently, a contradiction may arise from this view as why more searches do not imply more information!

But this apparent contradiction is attributed to the assumption that atoms and other quantum entities are “Kantian things themselves” but they are not [6]. They could not be experience by observer; Kant states that we cannot say anything about thing itself as we could do on objects of our perception. He assumed that things which are similar to thing itself can be correlated. In other words, he considered the structure of experiences in daily life as a “priori”. In terms of Kant Philosophy, the world consists of things which are distributed in space and they change in time according to a set of rules. But in quantum mechanics observations cannot be correlated like “thing in itself” as there are not atoms or subatomic particles in themselves**.** In Kant philosophy thing itself cannot appear even indirectly. In classical sciences, this concept corresponds to those things which we cannot know about them and a prior knowledge is just a function to make experience possible. In this philosophy, atoms, which cannot be seen, are objects but we can understand them as they are observable through phenomena.

In the apparent world it is not possible to separate things that we directly see from things that we deduce. If two observational situations are correlated in quantum mechanics then the complementary principle states that complete information on one of them means a total lack of information on another. This, of course, means that Kant philosophy analysis for experience is no longer accurate in quantum mechanics even though it is correct in classical mechanics. The intuitive form of space and time are not absolute but relative and as a result category of causality is too. The uncertainty is something purely subjective and Kant a priori concepts hold true in quantum mechanics but they are relative and not absolute [34][6].

An electron in an atom can be in different positions at the same time. On the other hand, particles can be entangled. Two or more particles that are far apart, for example several billion kilometers, are correlated in an unexplained way and anything happens to one of them causes an instantaneous change in others [35][36].

In quantum mechanics, we must ignore our fixed idea by our senses on macroscopic world and mathematics should lead us in our discovering of nature. Atomic and subatomic particles exist in a mathematical space known as Hilbert space which is deferent from our space. This space managed to explain mysterious behaviors of quantum world. This is why physicists in their work to discover nature use mathematics to predict what happens in the future. This is attributed to the fact that physicists and human in general, have not any intuitive idea on atomic and subatomic world.

At the end, we return to our first question which was “why Hawking thinks philosophy is dead!” This is one of the Hawking’s challenging sentences and of course an imprecise sentence [37-38].

But in comparison with quantum mechanics, classical physics relies on our sense to understand nature and there is a great philosophical system known as Kant philosophy that complements the classical physics. In modern science, physicists get less help from the philosophy but instead they resort to mathematics for innovation. Hawking does not explicitly say what the alternative of philosophy is, but Heisenberg stated in his time that mathematics is the alternative [21][6]. Of course, this may not mean that philosophy is dead but is applies only for conception in macroscopic world.

References

[1] S.Hawking and L. Mlodinow, “The Grand Design”, Bantam Book, New York (2010).

[2] Christopher Norris, “Hawking Contra philosophy”, Philosophy Now ,Volume 82, (2011).

[3] Sally Parker-Ryan, "Ordinary language philosophy", The Internet Encyclopedia of Philosophy (2012).

[4] Shiro Ishikawa, “Quantum Mechanics and the Philosophy of Language: Reconsideration of Traditional Philosophies”, Journal of Quantum Information Science(jqis), 2, 2-9, (2012), DOI: 10.4236/jqis.2012.21002.

[5] BS DeWitt, “Quantum mechanics and reality” , Physics today, 1970.

[6] W Heisenberg, “Physics and beyond: Encounters and conversations”, Harper and Row publisher London (1971).

[7] George Gamow, “thirty years that shook physics”, Doubleday&company , Newyork (1966).

[8] A. A. Ross-Bonney “ Does God play Dice, A Discussion of some Interpretations of Quantum Mechanics” Il Nuovo Cimento B Series 11, Volume 30, Issue 1, pp 55-79 (1975).

[9] Birger Hjørland, "Empiricism, rationalism and positivism in library and information science", Journal of Documentation, Vol. 61 Iss: 1, pp.130 – 155 (2005) DOI: 10.1108/00220410510578050.

[10] A Weber, FJ Varela, “Life after Kant: Natural purposes and the autopoietic foundations of biological individuality”, Phenomenology and the cognitive sciences,1: 97–125, 20 Springer (2002).

[11] S. Hawking, “The Universe in a Nutshell”, Bantam Books (2001).

[12] Helge Kragh, “Quantum Generations: A History of Physics in the Twentieth Century”, Princeton University Press, (1999).

[13] Vladimir B. Braginsky, Farid Ya Khalili, “Quantum Measurement”, Cambridge University Press, (1992).

[14] Y Aharonov, J Anandan, L Vaidman, “Meaning of the wave function” , Physical Review A(1993).

[15] M Born, “The interpretation of quantum mechanics” ,The British Journal for the Philosophy of Science, (1953) – JSTOR.

[16] W. Heisenberg, “the physical principles of the quantum theory”, University of Chicago press (1930).

[17] Angelow, A ; Batoni, M C, “About Heisenberg Uncertainty Relation (by E. Schrödinger)”, Bulg. J. Phys. 26, 5-6 , pp.193-203 (1999).

[18] Niels Bohr, “ON THE NOTIONS OF CAUSALITY AND COMPLEMENTARITY”, Dialectica, Volume 2, Issue 3-4, pages 312–319, November (1948) , DOI: 10.1111/j.1746-8361.1948.tb00703.x.

[19] Feynman, Richard Phillips,”The principle of least action in quantum mechanics”, PhD Thesis, Princeton U. (1942).

[20] Sakurai, Jun John; Napolitano, Jim, “Modern quantum mechanics”, Addison-Wesley(2011).

[21] AD Aczel , “Entanglement: the greatest mystery in physics”, Raincoast Books, (2002).

[22] Copleston, Fredrick, A History of philosophy,volum1, p.328. image books,(1962).

[23] Shabel, Lisa, Kant and modern philosophy,p.102-103 camberidge,(2006).

[24] Jay F. Rosenberg, introduction to the critique of pure reason,p.89-91,oxford,(2005).

[25] Kant Immanuel, critique of pure reason, p.304, Cambridge,(1998).

[26] Kroner, Stephan "Kant" p.25-32, Penguin (1990).

[27] Smith, Norman K.," A Commentary to Kant`s Critique of Pure", p.361-362, the Macmillan Press LTD, 1995.

[28] Copleston, Fredrick, A History of philosophy,volum5,p.281.image books,1994.

[29] Hartnack, Justus, Kant's theory of knowledge.

[30] RP Feynman, RB Leighton, M Sands, "The Feynman Lectures on Physics," vol. III, p. 18-9 (1965).

[31] John Ellis,John S. Hagelin1 D.V. Nanopoulos, M. Srednicki, "Search for violations of quantum mechanics", Nuclear Physics B, Vol. 241, Issue 2, Pages 381–405 (1984).

[32] CF Weizsäcker, "The Copenhagen interpretation", Quantum Theory and Beyond, Cambridge, (1971).

[33] J. S. BELL, "ON THE EINSTEIN PODOLSKY ROSEN PARADOX" Physics Vol. 1, No. 3f pp. 195—200, (1964).

[34] J Faye, "Copenhagen interpretation of quantum mechanics", Stanford Encyclopedia of Philosophy (2008) .

[35] Giacomo Mauro D'Arianoa, Franco Manessia, Paolo Perinottia, "Spooky action-at-a-distance in general probabilistic theories" Physics Letters A Vol. 376, Issue 45, Pages 2926–2930, (2012).

[36] Shahen Hacyan, "Einstein's "Spooky Action at a Distance" in the Light of Kant's Transcendental Doctrine of Space and Time" AIP Conf. Proc. 861, 1117 (2006)**.**

[37] Hossieni et al, "FROM QUINTESSENCE TO SPOOKINESSEVOLUTION OF SUPERNATURAL IN PHYSICIST MIND", European Journal of Science and Theology, 13 (2017), 1, 117-125

[38] Hossieni, H., "On God's Supernatural Role in Hawking's Literature", September 2016, Volume 7, Issue 8, pp. 482-491