CSCanada
Canadian Social Science
Vol. 9, No. 2, 2013, pp. 7-10
DOI:10.3968/j.css.1923669720130902.2678

ISSN 1712-8056[Print]
ISSN 1923-6697[Online]
www.cscanada.net
www.cscanada.org

Philosophical Inclusion in the Measurement Problem in Quantum Theory

Kyrian A. Ojong[a],*; Emmanuel Iniobong Archibong[b]

[a] Faculty of Arts, Department of Philososphy, University of Calabar, Nigeria.
[b] Faculty of Arts, Department of Philososphy, University of Uyo, Nigeria.
*Corresponding Author.

Received 1 February 2013; accepted 10 April 2013

Abstract

Measurement problem in quantum theory is informed by the difficulties which howbeit, fall under philosophical investigation involving the behavior of sub-atomic particles, especially as it has to do with interaction between the mental and the physical. This problem dates back to antiquity with the belief in the duality of mind and body (mental and material) as distinct essences of nature. This paper is an attempt to highlight the issues involved in the measurement problem in quantum theory, while at the same time showing that the resultant paradoxes encountered in the process have always been present; they are just a resuscitation of ancient problems that philosophers have reflected upon as regards the description of physical reality.

Key words: Measurement; Perception; Macro-world; Micro-world; Inclusion; Materialism and Idealism

Kyrian A. Ojong, Emmanuel Iniobong Archibong (2013). Philosophical Inclusion in the Measurement Problem in Quantum Theory. *Canadian Social Science, 9*(2), 7-10. Available from http://www.cscanada.net/index.php/css/article/view/j.css.1923669720130902.2678
DOI: http://dx.doi.org/10.3968/j.css.1923669720130902.2678

INTRODUCTION

The measurement problem is at the heart of quantum theory. This fact is predicated on Physicists' quest for "certain" and "indubitable" knowledge of the physical world, thus enhancing accurate prediction which is held to be one of the goals of science. In quantum mechanics it is shown that, two physical quantities described by non-commuting operators cannot be simultaneously measured with perfect accuracy, and the relation between these two quantities can be derived from a wave function. The problem put forward by Einstein, Podolsky and Rosen (EPR) is that the description of physical reality as given by the wave function is not complete. EPR paper raises a fundamental criterion of reality and locality which later led to the development of hidden variable theory of quantum explanation.

In the collapse of wave packet, Schrodinger shows a constellation of puzzles known as the measurement problem using the Schrodinger's cat. This was a thought experiment to show how quantum theory treats radioactive decay. Measurement arises when a matter wave interacts with a macroscopic measuring device. This collapse is sometimes attributed to an intelligent human agent who actually does the observing.

The measurement problem is not just an interpretational difficulty peculiar to quantum mechanics. It also has philosophical perspectives, especially as it has to do with the Lockean realist account according to which perception involves the creation of an "inner reflection" of an independently existing reality, and the Kantian "anti-realist" concept of the "veil of perception". The collapse into one or the other of these two components, which is (a dead or a living cat) only arises when we take measurement.

The quantum world symbolizes the external world and what goes on out there is different from the world delivered by our raw senses. How then can we tell with exactitude what lies outside the realm of the senses? This question has great implication for our language and the striving for accuracy which science is known for via its purely empirical method.

Going by the paradox of Max Born's probabilistic interpretation, Physicists are still faced with the problem of understanding how to use the apparently inconsistent ways of talking about atomic particles and light in the language of wave and particles. Gregory (1990) writes thus:

> Heisenberg's relationship, sometimes called the "uncertainty principle", says that physicists can determine an electron's position to any precision they like, but the more precisely they determine this position, the less precisely can they determine how the electron is moving at the same time (p.91-92).

Paradoxes are in the sphere of logic and not common place in the sciences. In the history of human intellect, two different schools of thought confront one another and they are known under the broad heading of materialism and idealism. Heisenberg in Burke (1987) once quipped that: Strangely enough, this old question of materialism or idealism has brought up again in a very specific form by modern atomic physics and by the quantum theory of Max Planck in particular (p.523).

We have epistemic access to two distinct kinds of phenomena; the mental and the physical, or the experiential and non-experiential. We also seem to have a strong intuition that there is an intimate relationship between the two phenomena; but our current conceptual systems seem wholly inadequate in offering a coherent account of this relationship. As Osei (2006) rightly opines, "this is the perplexity that afflicts our human conditions" (p.10).

When the physical sciences begins to participate in the questions that are wholly philosophical, especially as it relate to the physical and mental realities, it keeps our minds wondering about the possibility of breaking through the kernel of physical reality without some iota of speculation. The measurement problem in quantum theory therefore, seems to waiver around the traditionally dominated mind-body debate in philosophy. For measurement must involve the thing to be measured and the measurer. Thus in distinguishing the two clearly, it will doubtless pose problems which at best will fall under philosophical categorization of what reality constitutes in quantum theory.

Understanding The Notion Of Measurement

Measurement can be described as an interaction between an object and an observer, or even as a synthesis of the two. The observer can also mean a cognitive subject with his full psychical equipment; as well as a classically describable apparatus. If a difference between an observer and his equipment is not made, and if an observer is allotted a supra physical mind, say an immortal soul, then measurement becomes a gate through which soul and spirit flow not only into the making of physics, but also into the things themselves, which thereby cease to be things in themselves (Bunge,1973: p.71).

Measurement is a foundation stone of the edifice of modern science, along with experimentation so often necessary for exact measurement. Durbin (1968) puts it thus: it was exact measurement that made the difference between Galileo and the Aristotelians of his day; his 'new sciences' were distinctively precise in so far as they gave preeminence to mathematical measurable effects (p.126). Again, Kuhn claimed that "a quantitative precision strikingly better than its older competitor is one of the hall marks of nearly every revolutionary advance in the history of science" (Kuhn,1957:p.152).

MEASUREMENT PROBLEM IN QUANTUM THEORY

In quantum theory, the measurement problem ultimately shows the inseparability of the observer from the observed. There is no measurable, solid reality "out there" independent of the measurer. What is 'out there' when we are not looking is an infinite wavy cloud of criss-crossing possibilities. Then when we focus our attention on something, the wave function collapses into a defined particle in a definite location for us to observe (Esoterics 2010).

Thus measurement problem raises a central question about the role of the observer in quantum reality. We infer that the photon acts like a wave when we are not looking, but we never actually see those waves. So what causes the photon to "collapse" into a particle when we do decide to look at it? David Albert (1992) puts the problem succinctly when he says:

> The dynamics and the postulate of collapse are flatly in contradiction with one another; the postulate of collapse seems to be right about what happens when we make measurements and the dynamics seem to be bizarrely wrong about what happens when we make measurement and yet the dynamics seem to be right about what happens whenever we aren't making measurement (p.72).

What David Albert is saying here is that the more accurate we measure the velocity (dynamics) of a particle, the less accurate we are on the position which he refers to as the postulate of collapse so that measurement can affect the particles one way or the other. Thus what goes on when we are not measuring is always right and, that is the aspect science cannot know. In quantum physics, the probability of an event is deduced by taking the square of the amplitude for an event to happen.

The term "amplitude for an event" arises because of the way Schrödinger's equation is derived using the mathematics of ordinary classical waves where the amplitude over a small area is related to the number of photons hitting the area. In the case of light, the probability of a photon hitting that area will be related to the ratio of the number of photons hitting the area divided by the total number of photons released. The number of photons hitting an area per second is the intensity or amplitude of the light on the area; hence the probability of finding a photon is related to the amplitude.

However, the Schrödinger equation is not a classical wave equation. It does not determine events; it simply tells us the probability of an event. In fact, the equation in itself does not tell us that an event occurs at all, it is only when a measurement is made that an event occurs. The measurement problem asks how a definite event can arise out of a theory that only predicts a continuous probability for events.

Two broad classes of theory have been advanced to explain the measurement problem in quantum theory. In the first theory, it is proposed that observation produced a sudden change in the quantum system so that a particle becomes localized or has a definite momentum. This is known as collapse of the wave function. In the second, it is proposed that the probabilistic Schrödinger equation is always correct and that, for some reason, the observer only observes one particular outcome for an event. Bell (2004) puts it this way: "despite more than seventy years of interpreting quantum mechanics and resolving the measurement problem, the Bohr interpretation in its more pragmatic less metaphysical forms remains the "working philosophy" for the average physicist" (p.189).

What Bell is trying to say is that Bohr's principle of complementarity helps solve the problem of measurement in the sense that particle is complementary to wave and vice versa. This notion it seems, has helped to quell the difficulties encountered in this dual behavior of matter as waves and particles. It seems to be a milder solution to the problem even though complementary are not equivalent and may have different ontological status.

THE PHILOSOPHICAL ANGLE TO THE MEASUREMENT PROBLEM IN QUANTUM THEORY

The philosophical debate that has similar bent with the measurement problem is realism and idealism. Realism in its strictly philosophical sense is the position that the objects of our senses are real in their own right; they exist independently of their being known to, perceived by, or related to the human mind. For the realist, the universe is so inexorably "out there" that the only thing we can do is to come to the best terms possible with it.

On the other hand, the idealists contend that an object known or experienced is different from the object before it entered into such relationship. Since we can never know an object except as it is known or experienced by us, the object's being known or experienced tend to modify or constitute the object to some extent. The realist holds that such reasoning is fallacious, because it draws a false conclusion from certain accepted propositions. We cannot of course know what qualities a thing possesses where it is unknown. The only valid conclusion is that all known things are known which is a truism, or that awareness is an element in knowledge. From this we cannot draw the conclusion either that things have no qualities when they are not known or that the experience of knowing changes them in any way or constitutes their existence.

Realism insists that the widely accepted common sense position is sound, that is, that the realm of nature or physical objects exists independently of us and that our experience does not change the nature of the object experienced. If this realist position is tenable, then quantum theory must answer why measurement distorts or makes elusive the determinate position and velocity of an electron or particle simultaneously. Furthermore, quantum theory should be able to say why we cannot know the state of a particle until an observer comes into the picture.

Measurement can interact with the system state in somewhat peculiar ways as is illustrated by the double-slit experiment which is still the best way to show how sub-atomic particles can act as waves and as particles. The Schrödinger's cat in the box experiment is the best analogy of the double slit experiment. In addition to the unpredictable and irreversible character of measurement processes, there are other elements of quantum theory that distinguish it sharply from classical physics and which are not present in any classical theory. One of these is the phenomena of entanglement, as illustrated in the EPR paradox, which violates the principles of causality.

Quantum entanglement occurs when an electron or photon, interact physically and then become separated; the type of interaction is such that each resulting member of a pair is properly described by the same quantum mechanical state which is indefinite in terms of position, momentum and so on. When a measurement is made and it causes one member of such a pair to take on a definite value, (clockwise spin), the other member of this entangled pair will at any subsequent time be found to have taken the complementary value (counter clock wise spin). Thus there is a correlation between the results of measurements performed on entangled pairs and this occurs even though the entangled pair may have been separated by arbitrarily large distances.

According to Christian (2009), "particles can affect one another from a distance even when no force or connection exists between them; "spooky action at a distance" was Einstein's description of it, and he fairly rejected the notion (p.517). David Hume had attacked induction from the position of a necessary connection because of something being the cause of another. There is no doubt about their conjunction, but no evidence can be found for their connection. The idea of necessity is a metaphysical notion for which experience affords no warrant. We can assume the probability of a certain future occurrence on the basis of previous experience, but there is no reason why the future should conform to the past (Tsambassis, 1967, p.124).

Also the precise ontological status of each interpretation in quantum theory remains a matter of philosophical argument. In other words, if we interprete the formal structure X, of quantum theory, by means of a structure Y (via a mathematical equivalence of the two structures), what is the status of Y? Mathematics is a mental construct that is closer to metaphysics in nature and it is only those who understand what a functional correlation represents that can actually make meaning out of it or tell us what it corresponds to. Russell (1948) puts this point more lucidly when he states thus:

> Mathematical physics contains such an immense superstructure of theory that its basis in observation tend to be obscured. It is, however, an empirical study, and its empirical character appears most unequivocally where the physical constants are concerned (p.44).

Interpretational difficulties in quantum theory is contingent upon a lot of factors chiefly that quantum equations differ from those of classical physics in a very important respect, namely that they are not "linear". This means that when one has discovered the effect of one cause alone, and then the effect of another cause alone, one cannot find the effect of both together by adding the two previous effects. In quantum theory, there is less dependence of causes than in classical physics, and this adds greatly to the difficulty of the calculation; thus prediction and control which is one of the basic aims of science, suffers serious blow.

The problem of measurement is thus linked to the claim that in the course of determining the position and momentum of a quantum particle, the instrument or apparatus of our measurement affects or distorts either its position or velocity so that we cannot determine the two simultaneously. The challenge before us is that there is an interaction of consciousness and matter when observation is carried out at the micro or quantum level. Thus quantum theory, going by the Copenhagen interpretation which seems to go down well with majority of physicists connects to the problem of psychophysical interaction or mind related problem which is exclusively in the purview of psychology and not physics.

CONCLUSION

There are certainly a number of questions to be raised regarding the connection of the quantum world to the world of macro and observable objects to the extent that quantum theory has no satisfying theory to explain why quantum objects collapse when they encounter observational measurement. Quantum mechanics also bring us no relief as regards the weirdness about the relationship between matter and consciousness.

Though Roger Penrose's (1986) suggestion that there is a purely physical explanation for the collapse of the wave function when the right quantity of matter has gathered in a certain point is refreshing and ought to be welcomed. His account might help us to construct a theory to explain how determinate macro objects arise out of the indeterminacy of superposed states.

However, this does not explain why quantum particles individually seem to have a double existence and at the same time slice, as the double slit experiment seems to suggest. It does not tell us why a relatively simple quantum system like an electron is capable of collapsing to form a particle by observation. So there is still some ignorance about the way that matter in its simple forms behaves, if quantum mechanics were true.

Contradictions and paradoxes often do not allow for "certain" knowledge. And nature from our findings so far is riddled with a lot of paradoxes and contradictions as regards its occurrences. Even to advanced physicists, the question of why subatomic particles can act as both waves and particles is still a puzzle. Science, from our findings so far in the light of quantum theory, (it appears) will make more progress if other modes of inquiry such as ontology and logic are brought into its enterprise not loosely or dogmatically and it is this inclusion that this paper sought to show.

REFERENCES

Albert, D. (1992). *Quantum Mechanics and Experience*. Cambridge: Harvard University Press.

Bell, J. S. (2004). *Speakable and Unspeakable in Quantum Mechanics*: *Collected Papers on Quantum Philosophy*. Cambridge: Cambridge University Press.

Bunge, M. (1973). *Philosophy of Physics*. Dordrecht: Reidal Publishing.

Christian, J. L. (2009). *Philosophy: An Introduction to the Art of Wondering* (10th ed.). Belmont: Wadsworth Centage Publishers.

Esoterics, E. (2010). *Quantum Mechanics: The Measurement Problem*. Retrieved from http//www.evidubay.bloyspot.com/2010/02/quantum mechanics measurement Problem-html

Gregory, B. (1990). *Inventing Reality: Physics as Language*. New York: John Wiley and Sons.

Heisenberg, W. (1987). Philosophical Problems of Atomic Physics. In John G. Burke (Ed.), *Science and Culture in the Western Tradition.* Scottsdale: Gorsuch Scarisbrick.

Kuhn, T. S. (1957). *The Copernican Revolution*: *Planetary Astronomy in the Development of Western Thought*: Cambridge: Cambridge University Press.

Osei, R N. (2006). *The Mind-Body in Philosophy: An Analysis of the Core Issues*. Ibadan: Hope Publishers.

Penrose, R. (1986). Big Bangs, Black Holes and Time's Arrow. In R. Flood and M. Lockwood (Eds.). *The Nature of Time.* New York: Black Well Publishers.

Russell, B. (1948). *Human Knowledge: Its Scope and Limit.* London: George Allen and Urwin.

Tsambassis, A. N. (1967). *Human Experience and its Problems: Introductory Readings in Philosophy*. Belmont: Wadsworth Publishing Company.