



# MIND INDEPENDENT WORLD: INTERFACE OF SCIENTIFIC REALISM AND QUANTUM PHYSICS

Satwant Kaur<sup>1</sup>, Piyush<sup>2</sup>, Desh Deepak Singh<sup>2</sup>, Chirmi Acharya<sup>3</sup>

Corresponding Author: Desh Deepak Singh<sup>2</sup>

Address: <sup>1</sup>Department of Humanities and Social Sciences, Indian Institute of Technology, Delhi

<sup>2</sup>Amity Institute of Biotechnology, Amity University, Rajasthan

<sup>3</sup>Amity Institute of Behavioural and Allied Sciences, Amity University, Rajasthan

## ABSTRACT

The paper looks into one of the most debatable topics in the realm of philosophy of science—the relationship between scientific realism and quantum mechanics. To commence, the subject matter of scientific realism and basic concepts of quantum mechanics will be familiar. The briefing on the EPR paradox and Bell's theorem will develop an understanding of how quantum mechanics is used in refuting the mind-independent domain of the metaphysical thesis of scientific realism. Elucidation of the measurement problem will be carried out to understand that the cognitive abilities of an observer do not intervene in the measuring process. It will be observed that despite the measurement problem, the existence of a mind-independent world cannot be denied.

DOI Number:10.14704/nq.2022.20.8.NQ44349

NeuroQuantology 2022; 20(8): 3187-3194

3187

## INTRODUCTION

Over the centuries of philosophical progress, there remains a lack of consensus and conclusive stand over the understanding of the term realism. If understood in basic and layman's terms, realism may be understood as a philosophical viewpoint that regards the objects of perception as real, i.e., they exist in the world and are not merely abstract ideas in the mind as propounded in the Idealistic philosophy. Moreover, these objects of perception are real, independent of our knowledge of them, and their existence is not limited by our ability to perceive them. Consider the following views of thinkers about realism:

There are two general aspects to realism, illustrated by looking at realism about the everyday world of macroscopic objects and properties. First, there is a claim about *existence*. Tables, Rocks, the moon, and so on all exist, as do the following: the table is square, the rock is made of granite, and the moon is spherical and yellow. The second aspect of realism about the everyday world of macroscopic objects and their properties concerns *independence*. The fact that the moon exists and is spherical is independent of anything anyone happens to say or thinks about the matter [1].

Realism is a concept that applies to the domain of various subject matters, including

mathematics, aesthetics, science, and semantics, among others. One can assert a realistic association with all these subject matters, or a partial approach can be followed. That is, one can be an aesthetic realist but at the same time scientific anti-realist. Generally, universal realism is not witnessed among philosophers, and selective realism finds itself in the light. For further clarity of the terms, considers [Williamson \(1995\)](#), who describes realism and a realist as following [2]:

"To assert that something is somehow mind-independent is to move in the realist direction; to deny it is to move in the opposed direction ... Many philosophical questions have the following general form: Is such-and-such mind-independent in so-and-so way? Given specifications of such-and-such and so-and-so, one may call someone who answers "Yes" a realist". For the sake of this paper, the focus will be on the scientific realm of realism.

### SCIENTIFIC REALISM

Even after decades of debate about scientific realism, it is still baffling that we struggle to understand what is precise, as understood by philosophers. Is it a belief in the epistemic status of scientific theories? Moreover, what is to be the account for such a belief? Is it rationality? Alternatively, as put forward by [Brad Wray \(2018, p. 1\)](#), "Do we have adequate grounds for believing that our theories are true or approximately true concerning what they say about unobservable entities and processes?" [3].

As per [Mizrahi \(2020\)](#), Scientific realism refers to the epistemologically positive attitude toward the aspects of scientific theories that are worthy of belief. In other words, the belief regarding the claims about the theoretical knowledge concerned with unobservable entities, processes or theories is valid. On the other hand, Anti-realists showcase a sceptical attitude towards the theoretical posits of such scientific theories [4]. In other words, scientific realism believes in the scientific theories positively that have unobservable entities underlying them. If the theories so considered

are approximately true most of the time, the unobservable entities that it poses do exist. For example, there is no way to know why gravitational force exists in the world, but theories that show its presence and corresponding facts in the world make the theory worthy of belief and hence belief in the claim that gravitational force exists as well. In the contemporary scientific realism/antirealism debate, while there are multiple stands to understand it, the general view may be summarised as associated with one or more of the following three theses/ stances, as explained by [Psillos \(2006\)](#):

"The Metaphysical Thesis: The world has a definite and mind-independent structure.

The Semantic Thesis: Scientific theories are truth-conditioned descriptions of their intended domain. Hence, they are capable of being true or false. The theoretical terms featured in theories have the putative factual reference. So if scientific theories are true, the unobservable entities they posit populate the world.

The Epistemic Thesis: Mature and predictively successful scientific theories are well confirmed and approximately true. So entities posited by them, or, at any rate, entities very similar to those posited, inhabit the world" [5].

The metaphysical thesis of scientific realism is about a mind-independent world which implies that the observable and unobservable entities of the world have an existence independent of the cognitive abilities of our mind to know and understand them. In simple words, observable entities like trees and chairs exist whether or not someone is looking at them, unlike the views proposed by Berkeley – *esse est percipi*. Similarly, the unobservable entities, not visible to naked eyes, also exist independently. [Bhaskar \(2015\)](#) also uses the distinction between transitive and intransitive objects of knowledge to make an understanding of the metaphysical thesis. Intransitive objects of knowledge are, in general, invariant to our knowledge of them: they are the real things and structures, mechanisms and processes, events and possibilities of the world, and for the most part, they are quite independent of us. If men ceased

to exist, the sound would continue to travel and heavy bodies fall to the earth in the same way, though ex hypothesi there would be no-one to know it. The transitive objects of knowledge are Aristotelian material causes. They are the raw materials of science—the artificial objects fashioned into items of knowledge by the science of the day. They include the antecedent facts and theories, paradigms and models, methods and techniques of inquiry available to a particular scientific school or worker [6]. It is this metaphysical thesis that generally found to conflict with the quantum mechanics. But for the sake of understanding, let us briefly understand the other stances as well.

The semantic thesis of scientific realism talks about scientific theories to be considered at their truth-value, that is, these theories can either be true or false. If the scientific theories considered are found to be true, then the unobservable entities that these theories posit exist in the world. However, how do we know if these scientific theories are true or false? When scientific realists talk about the truth of a theoretical statement, they typically understand it to mean "correspondence with reality" [7]. So truth and falsity of a scientific theory is validated by the corresponding facts in the world. Gravitational force is considered true because in reality gravity can be observed at approximately all the times. Hence, the semantic thesis can be observed in close relation to the epistemic thesis of scientific realism. That is, mature and predictable scientific theories are approximately true of the world. Therefore, it is only understandable to consider them true, approximately. So, if these theories are approximately true, unobservable entities posited by the world do exist in the world. Anti-realist tend to counter the epistemic thesis by pointing out that scientific theories that were considered true in one time period were proved to be otherwise in a different time. For example, it was long believed that our solar system followed a geocentric model but it was later known that the heliocentric model was actually in place. Hence, anti-realists portray scepticism towards the epistemic and,

therefore, the semantic thesis of scientific realism. Putnam (1975) tries to rescue the realistic approach when he says that "the positive argument for realism is that it is the only philosophy that doesn't make the success of science a miracle" [8]. How successfully did it rescue the epistemic realist approach is a debate for another time. But the biggest point of contention is related to the metaphysical viewpoint of scientific realism, where anti-realist inclines towards an observer-dependent world and denies the possibility of mind-independence. This point of contention is the main focus of this paper and it will be observed from the conflicting arena of scientific realism with quantum mechanics.

### **Scientific Realism and Quantum Mechanics**

There has been an everlasting discussion and debate about the nature of the relationship between scientific realism and quantum mechanics. Can both these concepts exist simultaneously? Or does one nullify the other? Has the advent of quantum mechanics put the validity of scientific realism under a scanner? Defenders of scientific realism refuse that quantum mechanics has added to any new problems in the realist view. While others are of the opposite viewpoint and believe that quantum mechanics has made the situation ripe for the end of the existence of the concept of scientific realism, or at least a revision in the concept. Regardless of atoning to one of the above two beliefs, it is clear that there seems to be some tension between these two viewpoints. And, to understand it, we must first get a basic understanding of quantum mechanics and why it is said to be in conflict with scientific realism.

### **Quantum Mechanics**

The subject matter of elucidation of the theories of quantum mechanics is closely associated with the process to begin deliberation on realism in the philosophy of quantum mechanics. Some of the most important theories are the EPR Paradox, Bell's inequality theorem and Kochen-Specker's theory.

To get hold of these theories and their relationship with scientific realism, we should go through concepts pre-requisite for their understanding. The advent of quantum mechanics can be traced back to de Broglie, who postulated that particles like electrons could also be understood as waves and that their wavelength ( $\lambda$ ) can be given as  $h/mv$  where  $h$  is Planck's constant and the denominator represents the momentum of the particle. This was then followed by the famous Schrodinger wave equation, explained in terms of a wave function which is used to predict the probability of outcomes or events in a quantum mechanical system. Further, in 1927, Heisenberg's Uncertainty Principle came to light. According to this principle, the measurement of a particle's position and momentum cannot be done at the same time. If the position of a particle is measured at time  $t$ , the momentum of a particle cannot be measured and vice versa. With this basic understanding of concepts in mind, we can move further to the theories.

#### THE EPR PARADOX AND BELL'S THEOREM

In 1935, Einstein, Podolsky, and Rosen (EPR) proposed a way to introduce an element of realism in quantum mechanics through a thought experiment. We must familiarise ourselves with the concept before going further.

To understand the experiment, consider a particle that decays into two spin-1/2 particles,  $A$  and  $A'$ , entangled. These two particles may travel far from each other spanning a distance of even thousands of light-years between them. Now, say we measure the spin coordinates of particle  $A$  along the  $y$ -axis at a time, say,  $t$ . The spin co-ordinate can be either up or down in the  $y$ -axis. However, according to the Copenhagen Interpretation of quantum mechanics, there is no possible way of knowing what it will be before an observation is made. But if the spin component of  $A$  is known, the spin component of  $A'$  can be known with certainty as  $A$  and  $A'$  are quantum entangled (because of the superposition of their wave functions).

Moving further, consider that the measurement of  $A$  is made at time  $t$  along the  $y$ -axis and the result showed upward spin. Therefore, even without measuring, it can be said with certainty that the spin of  $A'$  will be downward and upon measurement, it is found that the spin is downward along the  $y$ -axis. Moreover, if the experimenter wishes to know both the coordinates and tries to measure the particle's spin component along the  $x$ -axis as well, he would not be able to do so. This is because of Heisenberg's Uncertainty principle. It is now that it gets interesting. If no measurement is made of  $A$  along the  $y$ -axis, the experimenter will be able to measure the  $x$ -axis component of  $A'$  whereas the measurement of  $A'$  along the  $x$ -axis was not possible when a measurement was made along the  $y$ -axis for particle  $A$ . How does this happen? How do  $A'$  changes its behaviour depending on whether an observation is made of  $A$  or not? How does  $A'$  "knows" about the happenings of  $A$ ? Similar observations could be seen in the results of a double-slit experiment as well, where the inference pattern on the sheet at the back changed concerning the presence or absence of a measurement device. Does the presence of an observer or measurement device bring about a change in the reality as observed by us? That is, does it correspond to an observer-dependent reality and refutes mind-independent domain of the metaphysical thesis of scientific realism? Two explanations have been given concerning the EPR paradox to explain this behaviour:

1. Violation of locality principle:  $A'$  "knows" about the happenings of  $A$  because there is an instantaneous communication happening between them. Also, for instantaneous communication to happen, the communication speed must be greater than the speed of light which negated the special relativity.
2. Hidden variable:  $A'$  comes to know about the happenings of  $A$  because they have a huge amount of embedded information. This information guides the particles for their interactions in the future. The hidden variable can be understood as a sort of DNA

or pre-stored set of information on guiding principles. That is, when a particle comes to origin, it has all the information needed by it for all the possible future interactions. Consider the example discussed above, two particles A and A', both, have some embedded information since their origin. Therefore, when a change is made in one, it affects the behaviour of the other because that embedded information guides such kind of behaviour. What is baffling here is that particle A might be light years away from A' and might have interacted with thousands of other particles, so A' must have extremely high amount of data embedded inside to keep up with all these interactions.

Since the locality principle cannot be violated, so it was believed that either the hidden variable principle is true or the description of reality as given by wave function is incomplete. Consider the following statement by [Einstein, Podolsky, & Rosen \(1935\)](#), "In a complete theory there is an element corresponding to each element of reality. A sufficient condition for the reality of a physical quantity is the possibility of predicting it with certainty, without disturbing the system. In quantum mechanics in the case of two physical quantities described by non-commuting operators, the knowledge of one precludes the knowledge of the other. Then either (1) the description of reality given by the wave function in quantum mechanics is not complete or (2) these two quantities cannot have simultaneous reality. Consideration of the problem of making predictions concerning a system based on measurements made on another system that had previously interacted with it leads to the result that if (1) is false then (2) is also false. One is thus led to conclude that the description of reality as given by a wave function is not complete"[\[9\]](#).

This EPR paradox was followed by Bell's theorem of inequality which proved that there is no possibility of a hidden variable. For this, Bell considered the EPR experiment as described earlier. Let P (Q) be the device used for the measurement of the spin component of

A (A'). Moreover, Bell made the assumption of separability between the two devices. In other words, the result of the measurement of A by P depends deterministically on the direction say  $n$  ( $n'$  for P') and the hidden variables for A and A' and nothing else. From these assumptions, and using classical probability theory, Bell obtained in 1964 some inequalities for the combination of the results of measurements, involving a few well-chosen directions  $n$  and  $n'$ . The beauty of his result is that these inequalities are not always satisfied with the predictions of quantum mechanics. The reason for the discrepancy is due to the quantum description of the two-particle state. This is a so-called entangled or non-separable state, whose correlations cannot be properly represented by classical probability calculus. Experiments were carried out by several groups of researchers, the most precise results being obtained in 1982 by Alain Aspect and his team. The two particles were photons emitted by the same atom, and the spin measurements amounted to polarization measurements for the photons. The result was clear-cut on the side of pure, hard quantum mechanics against hidden separable reality[\[10\]](#). Therefore, [John S. Bell \(1964\)](#) proved that elucidation of quantum mechanics utilizing a concept of a hidden variable is not in line with the predictions of quantum mechanics. The concept of a hidden variable was looked at as the one which reinstated determinism and fulfilled the locality condition. But this was proven wrong when Bell breached a famous and established inequality [\[11\]](#). Various experiments carried out to prove Bell's theorem countered the 'local hidden variable theory' but not the non-local nature. His theory came out to be seen as a refutation of the epistemic thesis of scientific realism. Therefore, the possibility of a hidden variable was put down by Bell's Theorem and the experiments that followed it. So, it leaves us with the non-local conception of theory. There is no hidden variable in the unobservable entities posting the quantum world, which means the hidden variable cannot be used to rescue one from understanding the observer-

dependent world. Then how is it that a change in A brings a change in A'? The answer put forward inclines towards the observer dependence. It is only when a measurement is made in the first particle that the other particle shows a change. And the communication between the particles points to the violation of locality. But the main point of consideration here, concerning this paper, is if the measurement of particles carried out by an observer points to the cognition of observer been used to affect the results of the experiment and hence contradicting the metaphysical thesis of scientific realism. Also, why does the behaviour or properties of an object change when the experimenter decided to measure it? This is in contrast with the definite structure domain of the metaphysical stance of scientific realism. The following paragraphs will show how the measuring-measured apparatus remains the same concerning the presence or absence of an observer and how the metaphysical stance can be rescued.

#### **CO-EXISTENCE OF QUANTUM MECHANICS AND METAPHYSICAL THESIS OF SCIENTIFIC REALISM**

As it has been mentioned earlier, the advent of quantum mechanics has been understood to be directly in conflict with scientific realism, refuting it all together or seeking a thorough revision of realistic understandings. However, it is not the case. Quantum mechanics can stay put without de-rooting scientific realism. Generally, the metaphysical thesis of the scientific realism is considered as the tension between quantum mechanics and scientific realism. The main question, whose answer or lack of attainment of an answer is involved in this direct conflict, is: Is the mind-independent domain of the metaphysical stance of scientific realism breached when during quantum measurements, the properties of a measured structure or a measuring system are co-decided jointly by the measuring equipment or measuring device? Scientific anti-realists, as well as scientific realists who believe that a

revision is required in the realistic understandings, may provide an affirmative answer to the above question. They might believe that metaphysical stance is violated in such a case. This is so because, while describing quantum entities, cognitive methods come into force. Cognitive methods are methods deployed to attain or acquire knowledge, for example, thinking, remembering, etcetera and in this case, the measurement process. Since these cognitive methods come into play while measuring quantum entities, some of the descriptive properties of the measured quantum entities are jointly determined by the cognitive method of measurement. This leads to the conflict between the two realms.

As [Panagiotatou \(2017\)](#) point out, even though the measurement processes are impeding the descriptive properties of quantum entities, it should not be forgotten that the process of quantum measurement is a physical phenomenon. And it is recognised as a cognitive method when alongside the structure of measuring device- measuring system, a subject or an experimenter is added who not only performs the measurements but notes down the results as well. The physical process, in which the system interactions take place and measurements are carried out of the measured system, does not constitute the subject's or experimenter's mind. Hence, the subject's mind is not involved in the determination of the properties of the quantum observable entities. Experimenter's role is just limited to planning of the process which is represented by the measurements. It is because of the measurement process and carrying out of the experiments that the measured system or entities acquire the properties that they did not earlier possess, and not because of the interference or presence of the experimenter or observer [\[12\]](#).

Additionally, even in the case of basic quantum mechanics, contradictions do occur between the collapse postulate upon the measurement of a system and dynamics of the theory, without any regard to the presence or absence of an 'observer'. The addition or presence of an

observer in such a case seems to fulfil either of the two conditions: to resolve the contradictions that come to fore or to explain them. Thus, nothing justifies the addition of an observer to the process itself and risk getting the mind-dependent notion being attached to the whole process. The results that are seen occur because of the physical processes or facts that take place when the measurements are done. Just because the standard quantum mechanics equations are unable to explain why and how these measurement processes are responsible for the changes observed in entities or what exactly goes on during such measurements does not imply mind-dependence. Also, resorting to mind-dependence in such a case neither solve nor explain anything. Therefore, if the properties of certain entities change when the experimenter decides to measure it, it does not imply that the entity's reality is somehow lacking independence from the experimenter. It is for the reason of its nature and peculiar properties, which come into play when certain physical interactions materialize, that the reality of an entity is described. In no way is the presence of an experimenter a justifiable reason amounting to the changes observed in such quantum entities[12].

Moreover, the realistic approach does not imply that the definitive nature of the objects and their properties is independent of their exposure to a physical stimulus like measuring equipment. In other words, the definite nature of objects in no way portrays that their values will remain constant even when introduced to physical processes like measurements. The values will display a change with changes in the physical events. Some properties of an object are displayed when they encounter a specific physical phenomenon. Realists understand the definite structure of the world to include every theory that is out there in the scientific community to attribute to objects and their properties. Therefore, quantum mechanics being the best theory about the micro world is accepted by the realist. Also, what is revealed of the reality when exposed to quantum

experiments adds to the understanding of the definite structure of the world of objects[12]. So, it clear from the explanation put forward by Panagiotatou that if it is so that the result of A' changes when an observation is made or not made in A, the necessary conclusion is not an observer-dependent or mind-dependent world. A measurement system is a tool used to measure the values of a system or particle-like A, it does not display the cognitive abilities been used to affect the results of faraway things. The changes in A or A' happen because of their intrinsic qualities or features and it is these very features that are affected when they come in contact with the measuring device. The presence or absence of an observer along with the measuring device does not tend to affect the result of the measurements in any way. So, it is a wrong association that is made between the observers and the measuring-measured system. Moreover, the crude the definition or understanding of definite structure can be revisited. This explanation seems to rescue the metaphysical thesis of scientific realism – the existence of a mind-independent world – from the counter explanations provided in quantum mechanics.

#### **CONCLUSION**

The first section of the paper dealt with getting a better understanding of the key concepts. Scientific realism and its three components were discussed followed by the basics of quantum mechanics. The EPR paradox and Bell's theorem were made familiar to understand the contradiction with the metaphysical thesis of the scientific realism. The viewpoint that measuring apparatus used by observers refutes the existence of a mind-independent world is found to be misunderstood. The changes observed in the measured entities on being introduced to a measuring device do not negate the entity's independent existence. Moreover, the observer's mind or cognitive abilities are not part of the measuring apparatus and has nothing to add to the observed changes and results of the measured entities. Therefore, the metaphysical stance of scientific realism is

rescued from the observer-dependent notion put forward by the quantum world.

#### REFERENCES

1. Miller, A. 2002. "Realism". In *Stanford Encyclopedia of Philosophy*, <http://plato.stanford.edu/entries/realism>
2. Williamson, T. 1995. "Realism and Antirealism". In *Oxford Companion to Philosophy*, T. Honderich (ed.), 746–8. Oxford: Clarendon Press.
3. Wray, B. K. (2018). *Resisting scientific realism*. Cambridge: Cambridge University Press
4. Mizrahi, M. (2020). *The relativity of theory: Key positions and arguments in the contemporary scientific realism/antirealism debate*. Cham, Switzerland: Springer. doi:10.1007/978-3-030-58047-6
5. Psillos, S. Thinking About the Ultimate Argument for Realism. *Rationality and Reality*, 133–156. [https://doi.org/10.1007/1-4020-4207-8\\_8](https://doi.org/10.1007/1-4020-4207-8_8)
6. Bhaskar, R. (2015). *A realist theory of science*. Routledge, Taylor & Francis Group.
7. Psillos, S. (1999). *Scientific realism: How science tracks truth*. London: Routledge
8. Putnam, H. 1975. *Philosophical Papers*. Vol. 1, Mathematics, Matter and Method. Cambridge: Cambridge University Press
9. Einstein, A., Podolsky, B., & Rosen, N. (1935). Can Quantum-Mechanical Description of Physical Reality Be Considered Complete? *Physical Review*, 47(10), 777-780. doi:10.1103/physrev.47.777
10. Omnès Roland. (1999). *Quantum philosophy: understanding and interpreting contemporary science*. Princeton University Press.
11. Bell, J. S. 1964. "On the Einstein-Podolsky-Rosen Paradox." *Physics* 1: 195–200
12. Panagiotatou, M. (2017). Scientific Realism and Quantum Mechanics: Revisiting a Controversial Relation. *International Studies in the Philosophy of Science*, 31(3), 243–259. <https://doi.org/10.1080/02698595.2018.1463696>
13. Boyd, R. (1983). On the Current Status of the Issue of Scientific Realism. *Erkenntnis* (1975-), 19(1/3), 45-90. Retrieved December 22, 2020, from <http://www.jstor.org/stable/20010835>
14. Brock, S., & Mares, E. D. (2010). *Realism and antirealism*. Durham: Acumen.
15. Chakravartty, A., & Fraassen, B. C. V. (2018). What is Scientific Realism? *Spontaneous Generations: A Journal for the History and Philosophy of Science*, 9(1), 12. <https://doi.org/10.4245/sponge.v9i1.26992>
16. Dicken, P. (2018). *Getting science wrong why the philosophy of science matters*. Bloomsbury Academic, an imprint of Bloomsbury Publishing Plc.