

# Quantum Mechanics And Reality

Ever since the curiosity of man was at times rewarded by provable answers, his intellect steadily grew. After the stunning successes of Galileo and Newton's scientific works, intellectualism began to grow in power to rival religion. By the 19th Century many thinkers strongly believed that man's intellect, given the resources of experience and time, was capable of fathoming the mysteries of the physical universe.

Newton's physics was a gigantic milestone in the history of man. It unveiled the large-scale architecture of the universe, while many phenomena waited for the application of its principals to unlock their secrets. Man's knowledge of nature grew richer when Einstein rejected Newton's understandings of time, space, and gravity and formulated Theory Of Relativity to replace them.

But with the discovery of a discrete and irreducible quantum in the transference of radiation energy, Max Plank in 1900, reluctantly unleashed the phenomenon of discontinuity in the atomic world. Bohr's model of the atom in 1913 engaged many physicists' thinking about its plausibility and consequences. Further research in the atomic world indicated that Bohr's neat and simple model was untenable.

As more understanding of the underpinnings of the atom was sought, the old question of whether light was a wave or a particle resurfaced, even though in the last 200 years it was accepted as a wave. On the strength of Plank's discovery of the quantum of radiation, in 1905 Einstein concluded that light had a particulate nature, and the particles were later dubbed as photons. How did a negatively charged electron exist in the neighborhood of the positive nucleus? How did an atom absorb and radiate energy? Did the electron move around a nucleus or was it stationary at a point? The inner mechanics of the atom were a puzzle.

In 1924 de Broglie proposed the theory of matter waves in which particles could also exhibit wave characteristics. In 1925 Heisenberg proposed Matrix Mechanics, a matrix-based mathematical description of the mechanical system within an atom, incorporating de Broglie's idea, and only including the observable variables. That is, he used atom's spectroscopic properties like frequency and intensity, which were observable; while the position and momentum of an electron were excluded, as they were not observable. However, they could be deduced indirectly.

In 1926 Schrodinger proposed Wave Mechanics, using de Broglie's postulate on electron waves, where the particles were "bunched-up waves." Matrix Mechanics understood atom and its components to be particles, while Wave Mechanics understood them to be waves. Later Schrodinger and Dirac showed that Matrix Mechanics and Wave Mechanics were equivalent. Born renamed Matrix Mechanics Quantum Mechanics and stated that the wave in Wave Mechanics denoted not a classical wave but a probability wave, which indicated the probabilities of the location and momentum of a particle at a given point and time, and not the actual location and momentum. Later, in a new interpretation of Quantum Mechanics it was discovered that it already had the elements of the "probability wave" built in it. In the end Quantum Mechanics won the battle over Wave Mechanics.

Further development in Quantum Mechanics came in 1927 from Heisenberg who postulated the Uncertainty Principle theory, which became its cornerstone. Since position and momentum of quantum entities like electrons were not precisely observable, Heisenberg theorized that the more accurately you measured one, the more inaccurate would the other's measurement go. Exactly, the product of the uncertainties in the simultaneous measurements of the position and velocity of a quantum particle cannot be less than half of Planck's rescaled constant.

There is no proof for Uncertainty Principle; it is just a supposition, a mathematical construct expressing the idea of a physical reality, without a theoretical foundation or an experimental confirmation. Such an assumption followed

because measurements in the quantum world significantly disturb the quantum entities, unlike in the macroscopic world we are used to.

Inability to precisely identify position and momentum, also energy and time of its occurrence, in quantum world on account of the smallness of its objects, Uncertainty Principle would have been acceptable, but Quantum Mechanics states that nature is so built that there is inherent randomness in its architecture. This is the egregious notion of nature that is so disturbing, as modern science has believed that everything in the physical universe happens because of a cause. To abandon that structure of cause and effect at the most fundamental physical level of nature is unacceptable to many thinkers of the world.

What was the need to create such a theory? Men working in science are subjected to same human weaknesses as men everywhere else. Men working in the newly evolved quantum science in 1920's had wanted to give a closing to their findings and theories. They desperately wanted to reach the bottom of the quantum world. In their extreme eagerness to settle the knowledge of the basic building blocks of the physical universe, they even sacrificed its cardinal principle of cause-and-effect principle.

Quantum Mechanics states since the act of measurement in the quantum world disturbs the object being measured; therefore, you will never have complete information on the mechanics of the object. Measurement defines what is being measured.

Look at some of the strange implications of Quantum Mechanics. Since it believes nature is inherently random, when a quantum object goes from position A to position B, it is supposed to have no definite position during the travel; in fact, the object can take every possible path connecting positions A and B. It could take a path around the buildings in the neighborhood of the site of the experiment being performed or it could go around the star Alpha Centuri. This is called the

alternative histories of the reality. That is, all possible histories could have taken place between a particle's past and present locations; there is no unique history. Every time you look at a quantum object a new present reality is created and correspondingly there exist a range of its past and future realities.

Since the positions and velocities of quantum particles are unknown at any instant unless you make their observations, so therefore their pasts as well as futures are also unknown. It is only when you take measurements of their positions, momentums, and energies you create their present, and then you can project their probabilistic pasts and futures. Also, when you look at the universe of quantum particles, your "looking" disturbs it, that is, you will never know what it was like just an instant before your observation. You will never know exactly what the universe actually looks like at any time. Also, by observing it you are creating a new reality every time. So, we have a set of possible universes we live in.

Look at another application of Quantum Mechanics called delayed-choice experiment. Wheeler considered photons emitted by powerful quasars billions of light-years ago, which could now be split and refocused toward earth by the gravitational lensing of an intervening galaxy. By such an experiment, which is totally beyond our capabilities at this time, we could set up an interference of the two split beams. But if we used a device in our laboratory to find which of the two paths one of the light beam has travelled the interference will disappear, even when that decision to have an interference was taken by the beams billions of years ago.

This is all according to the standard Quantum Mechanics; conclusions with which many scientists disagree. All such bizarre scenarios have emerged from the probability interpretation of Quantum Mechanics.

Heisenberg's state of mind during the search of a theory for the quantum world

has been well documented. To begin with he detested philosophical aspects of Physics. If left to himself he would not have formulated the Uncertainty Principle. It was because of the heavy prodding of his boss Bohr that he desperately sought an explanation for why his 1926 theory on Quantum Mechanics downgraded the direct verification of position and momentum of quantum particles. In his frantic search for a theory he was reminded of what Einstein had once said about some situation in physics that it was the theory that decided what we can see. So, taking refuge from Einstein's philosophy Heisenberg's theory was going to prevent the simultaneously accurate measurements of the position and momentum of quantum particles. Heisenberg has stated that Bohr was not a physicist, but a philosopher.

Heisenberg thought that Einstein in his formulation of Theory Of Relativity abandoned the intuitively understandable and time-honored notion of the simultaneity of events. He thought that since Einstein gave up the popular notion of simultaneity because it was immeasurable, so he could also abandon the exact simultaneous measurements of position and velocity because that was not practically possible to do so. But that understanding of the formulation of Theory Of relativity by Heisenberg was flawed. Einstein had qualified that under certain conditions two events happening apart can qualify as simultaneously happening events. Also, Einstein never abandoned the-cause-and-effect principle. Heisenberg was desperate to explain his intuitive physical ideas by some theory, which Bohr insisted was necessary in order to conform to correspondence principle.

Bohr was a great physicist and one of the principal architects of Quantum Mechanics, but unfortunately some of his guidance of it was harmful. His creation of correspondence and complementarity principles to shore up the weak structure of Quantum Mechanics was flawed. He believed that nature may not always be comprehensible by human logic and therefore he said, "It is wrong to think that the task of physics is to find out how nature is. Physics concerns what we can say about nature." Bohr was a true-believer type of a scientist, for whom faith was more important than facts. He thought that since the quantum world was very different from the ordinary world, his two constructs would facilitate its understanding. But since these ideas were unscientific they introduced more

mythology to Quantum Mechanics than it already had. Instead of accepting man's inability to understand the entire quantum phenomena at the present, Bohr and his colleagues, who are collectively called the Copenhagen Interpretation Of Quantum Mechanics, created the two-science theory; one applicable to the quantum world and other to the macroscopic world. Bohr said that Quantum Mechanics demands a "final renunciation of the classical idea of causality." Einstein, Schrodinger, de Broglie, among the founders of Quantum Mechanics, disagreed with that interpretation. In 1935 Einstein, Podolsky, and Rosen's paper "Can Quantum-Mechanical Description Of Physical Reality Be Considered Complete?" seriously challenged some aspects of Quantum Mechanics. Bohr worked hard over nine months to give his response, which turned out to be weak and unconvincing. Till the end of his life Einstein complained about the incompleteness of the theory of Quantum Mechanics. He could never understand how the wave and particle descriptions of quantum particles were complementary, an idea highly patronized by Bohr. A few months before he died in 1954, Einstein invited Heisenberg to his home, and told him, "I don't like your kind of physics. There's consistency, but I don't like it."

So, the reality based on Quantum Mechanics is like an Alice-In-Wonderland phenomenon. But we do not have to accept all its tenets. It is quite likely because quantum particles are so minute that they do not behave like the Newtonian billiard-balls in their mechanics, but that does not mean we have to give up causality. We do not have to accept the idea that nature at its minutest level exists randomly, that cause-and-effect principal has to be sacrificed. We can accept our limitations in measurements in quantum world but we still have certainty associated with them in the macroscopic world.

There have been periods in the history of science when certain wrong ideas have persisted for decades. The idea that there was a substance called lumniferous ether enveloping all the matter in the universe, which facilitated the propagation of all electromagnetic waves, was accepted for a very long time, until Einstein decidedly got rid of the concept in 1905. In the same fashion we live in an era when the quantum particles are supposed to move around randomly by their own will. This will also pass one day in future and the causality in nature will regain its

absolute sovereignty. Until then we should keep our faith in it.

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