UNCERTAINTY IN THE HEISENBERG UNCERTAINTY PRINCIPLE

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ANNOSTATION.

The "uncertainty principle", one of the main principles of quantum physics, was proposed by the German physicist Werner Heisenberg in 1927. The uncertainty principle states that some properties of a subatomic particle, such as an electron, cannot be measured simultaneously with infinite precision. One pair that has an uncertainty relationship between them is momentum-position. First, the more uncertain the position of a subatomic particle, the more uncertain its momentum. The reverse of this relationship is also true. The order in which the measurement is performed changes the result. According to this result, revealed by the mathematical formulation of the Heisenberg Uncertainty Principle, there is a limit to what we can know about the universe. Accepting the idea that the wave-particle duality is the main cause of the uncertainties, Heisenberg emphasized that this situation arose as a feature of the physical structure of the universe and was not caused only by measurement. Such a result, of course, had philosophical consequences. Today, the picture of the universe revealed by the uncertainty principle is still a matter of debate among physicists and philosophers. This study aims to evaluate these philosophical considerations both ontologically and epistemologically.

Keywords: Heisenberg uncertainty principle, philosophy of quantum physics, philosophy of physics, history of physics, philosophy of science.

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During the period when modern physics was born, developments in physical science revealed the limits of classical physics theories in terms of explaining and understanding the universe. These developments have called into question the validity of many long-accepted principles of scientific research. The innovations under discussion appeared as less specialized but blurred problems. One of the biggest reasons why problems are described as indeterminate is, of course, the Heisenberg Uncertainty Principle. Werner Heisenberg, the scientist who put forward this principle, as the name of the principle suggests. Heisenberg developed the first and consistent mechanics of quantum processes in 1925, which was highly controversial at the time. During his time at the Bohr Institute in Copenhagen between 1924 and 1927, Heisenberg did some of his most creative work in quantum mechanics, including his interpretation of matrix mechanics and the uncertainty principle. Heisenberg, who gave a new identity to atomic physics with these studies, received the Nobel Prize in Physics in 1932 for his contribution to quantum physics.

Among the interpretations of quantum mechanics, Einstein's realism, Bohr and Heisenberg's Copenhagen interpretations, and von Neumann's hypothesis about the collapse of wave functions are prominent, although they represent two different interpretations of quantum physics, Von Schömansr. wave functions He showed that mechanics and Heisenberg's matrix mechanics are equivalent. With the uncertainty principle included in the Copenhagen interpretation, Heisenberg started the era of quantum mechanics in quantum physics. In other words, he made another revolution within the framework of the atomic revolution, which was just beginning to find its place in physics at that time. The reason that Heisenberg's great contribution is considered "revolutionary" is due to the many extraordinary features of his principle. It is necessary to distinguish three of these features from the point of view of their philosophical considerations. One feature is the mathematical structure required by this principle. This mathematical structure is now known as "matrix algebra". Heisenberg first introduced matrix algebra to physics through the uncertainty principle.

Heisenberg saw that the mathematical mechanism of quantum theory included inevitable uncertainty in predictions and distortion of the object during observation. The second feature is related to the result of the theory. That is, there is a limit to what we can know about the universe in which we live. This is due to the fact that what we can know at the limit is within the realm of possibility, governed by the laws of probability in terms of the general structure of the principle of quantum mechanics. Therefore, the fact that it requires multi-valued logic systems rather than classical logic for its control can be considered as a third characteristic. These emphasized features of the principle undoubtedly indicate that a new era has entered the philosophy of science in terms of both epistemological and ontological reflection. To evaluate these characters, the first part describes the Heisenberg Uncertainty Principle. The second section discusses the new mathematical framework used in the uncertainty principle to test the claim that there is a limit to what we can know, and then comments on the philosophical aspects of the principle. In conclusion, the "uncertainty" in the uncertainty principle is discussed within the framework of the principle's highlighted features and their philosophical interpretations.

In 1927, Heisenberg asserted that, according to the predictions of quantum mechanics, some pairs of variables such as "position and momentum" and "energy and time" cannot be determined "simultaneously" at a high and arbitrary level. kidded. members of the group of particles represented by the wave function ps. He put forward a mathematical thesis. The principle that explains this situation at the subatomic scale is called the Heisenberg Uncertainty Principle. The physical explanation of this mathematical thesis put forward by Heisenberg is as follows: The position and speed of an atomic particle cannot be specified together, at any time, and precisely. The position can be accurately measured, but then the interference of the tracking devices interferes with the velocity measurement to some extent. If velocity is measured first, then position cannot be learned at all. Planck's constant provides a lower bound for the result of these two uncertainties.10 In other words, if the position of a moving electron is to be determined precisely, it must be exposed to light of a certain wavelength. However, light rays falling on an electron cause the electron to move due to its mass. Therefore, the speed of the electron changes uncontrollably. In this regard, if the position of the electron can be determined more precisely, light beams of shorter wavelengths should be used.

However, the energy of the short-wavelength light is very high, and this light beam moves the particle in a way that causes it to have a speed greater than the actual speed of the electron. Thus, the possibility of determining the actual speed of the electron at that moment is lost. Therefore, this case "reveals the uncertainty that the position and velocity of an electron cannot be determined simultaneously." These explanations, according to Heisenberg, show that the concepts related to Newtonian mechanics do not take us far anymore, because in order to calculate the mechanical process, it is necessary to know the position and speed of the particle at a certain moment. But quantum theory has determined that this will not happen. Under these conditions, the future of subatomic particles cannot be accurately predicted or determined. According to Planck, the Heisenberg Uncertainty Principle has little to do with medium-sized physical objects. The "uncertainty" in the Uncertainty Principle comes from the fact that first determining the electron's position and then finding its velocity gives a different result than if we first determine the electron's velocity and then determine its position. The word "uncertainty" in the principle does not mean "uncertainty about the truth of the theory." This principle shows the uncertainty that is forced upon the application of classical Newtonian concepts such as "particles" in the description of a physical system. This case is discussed in detail under the heading of mathematical structure. The Heisenberg Uncertainty Principle also involves uncertainty. reveals the energy and time couple.

In other words, the more precise our knowledge of time, the more imprecise our knowledge of energy. In this case, according to the uncertainty principle, as our knowledge of time increases, our knowledge of energy decreases. These results show that there is a limit to what we can observe, regardless of the improvement of measuring instruments and methods. According to Hutten, the uncertainty "must be considered as a fundamental property of the electron, not as evidence of the inapplicability of the wave picture." This remarkable result actually comes from the mathematical formulation of the Heisenberg Uncertainty Principle. Therefore, the mathematical structure of the principle is discussed below.

Heisenberg used a new type of mathematics to explain motion on the subatomic scale, which was initially considered strange by his contemporaries. He created the mathematical foundations of quantum mechanics using this mathematical system called "matrix algebra", which will be discussed below. Heisenberg showed how to evaluate tables consisting of rows and columns containing amplitude and frequency information about transitions between states at the subatomic scale. Heisenberg, who called these quantities "quantum theoretical quantities", related them to each other thanks to a calculation method he introduced called "quantum-mechanical relations". Using these tables and this method of calculation, he was able to obtain formulas similar to those in classical mechanics. This method of mathematics led to a significant increase in the ability to calculate and predict quantum phenomena. This mathematical method is different from classical mathematics. In classical mathematics, there is a property of "change" in multiplication.

For example, 3x4=12 and 4x3=12. So 3x4 = 4x3. In other words, it doesn't matter in which order the numbers are multiplied. They give the same result regardless of the order of multiplication. However, this rule is not valid in Heisenberg's method of calculation. In the case of atoms, Heisenberg found that the variables he multiplied produced different results depending on the order in which they were created . In other words, AxB and BxA gave different results. In other words, the order of certain properties, such as where the electron is at a given time and how fast it is moving when multiplied together, changes the result. In other words, this multiplication operation is not commutative. These

Heisenberg tables are mathematical objects that mathematicians call "matrices," and the new calculation method he developed is the same method mathematicians use to multiply matrices. The permutation rule does not apply to matrices. Thus, Heisenberg, together with his mentor Max Born, put forward the theory known today as Matrix Mechanics.

Heisenberg's new mechanics was not immediately accepted because of this mathematical feature, which most physicists at the time did not understand. However, this work was a remarkable theoretical mathematical development that managed to describe how atoms behave. "The continuous discrete mathematics of Heisenberg's theory was well suited to express the continuous, continuous, i.e. uncaused, structure of nature on which the Copenhagen school was based." The mathematical method required by the Heisenberg Uncertainty Principle is described as follows: Every quantity defined in classical mechanics corresponds to an operator in quantum mechanics. In the subatomic world, quantum mechanical operators (matrices) corresponding to different observables need not be commutative. That is, the order in which the observations are made can lead to differences in the actual observed values. For an operator corresponding to two noncommutative observations A and B, there is a general limit in quantum mechanics on how small ΔA and ΔB can be. there is a lower bound, or lower bound, to be in a number of dimensions of these variables at the same time.

LITERATURE ANALYSIS AND METHODOLOGY

The uncertainty principle has been able to explain many phenomena, including the cause of randomness in quantum theory. There is no uncertainty in the change of probability wave over time. The reason for this wave propagation is the uncertainty between position and momentum in the wave packet. Therefore, the propagation action occurs with impulses and velocities. However, the wave packet itself is still fully defined, they continue to propagate in time without any uncertainty. The so-called randomness occurs not because of the wave itself, but because it exhausts the possibilities of detecting the particle. In other words, uncertainty breeds randomness. According to Popper, this means mutual causality. The uncertainty principle does not apply to all features of the microcosm. For example, mass and electric charge have definite values that cannot be determined without uncertainty. Uncertainty applies only to certain pairs of variables (eg, position-momentum, energy-time), as mentioned above. These pairs are called conjugate variables.

This principle allows us to calculate the probability of obtaining a certain result when only one observation is made. It also places a necessary limit on what we can know and predict about the physical states of quantum phenomena. According to Planck, our ability to directly observe what laws apply to atomic phenomena through our measurements is gradually weakening. Planck suggests that the main reason for this is that the questions to be answered are becoming more and more sensitive, and our measuring instruments, each composed of atoms, cannot cope with this sensitivity. He gives an example of the situation: "An object cannot be drilled if the drill is larger than the object itself." This example is one of the examples that allows us to visualize the uncertainty principle. Heisenberg stated that observation itself plays an important role in the phenomenon, and reality itself differs depending on whether we observe it or not.

Heisenberg continues: "The term ``certainty'' as used in the natural sciences means that there has always been a set of concepts and systems of laws that form a closed whole and are explained by mathematical formulas. They are valid for some areas of experience. They hold universal truth for these fields; They do not support change or development. Therefore, these concepts and laws cannot be expected to represent new fields of experience. We can call the concepts and laws of quantum theory precise only in this limited sense. Scientific knowledge in this limited sense can sometimes be expressed precisely in the language of mathematics or another language." Planck supported Heisenberg's words and stated that quantum mechanics cannot give the position of an electron at a given moment, only the probability of the electron. In other words, Planck argued that quantum mechanics is a statistical law that gives the number of electrons that can be found anywhere at a given time in the total mass of electrons. , he noted. He also argued that the objective limit should be seen as a sign of the hegemony of a new kind of law. The ambiguity between position and momentum leads to certainty in the structure of atoms.

DISCUSSION AND RESULTS

As a physicist, Werner Heisenberg did not consider physics separately from philosophy. His extraordinary ideas in physics flourished as a result of the encouragement and questioning of philosophy, which he met long before physics. Heisenberg first encountered Plato's Timaeus during his high school years. Greek philosophy had a profound influence on Heisenberg. Heisenberg's words:

"While reading the Timaeus, I had the first opportunity to study Greek atomic philosophy from its original source. I thought I understood at least a little of why the Greek philosophers thought of infinitesimal and indivisible particles of matter. The view that atoms are real bodies, defended by Plato in the Timaeus, did not seem so clear to me. However, the belief that it is impossible to deal with modern atomic physics without knowing the Greek natural philosophy was firmly established in my mind even in those days.

According to Holton, Heisenberg's integration of these views of the atom with mathematical structure is a thematic choice in the Platonic tradition. caring theory. on intuition and empirical grounds." Although Heisenberg was influenced by Ernst Max in his youth, in his philosophical writings on quantum mechanics he strongly opposed the Logical Positivism developed by philosophers of science associated with the Vienna Circle. Heisenberg, I believe. not classical physics, but was influenced by philosophy. These can be seen as the reasons why he came up with deeper and bolder ideas about atoms. Unprecedented in the history of physics, the philosophical view of the Heisenberg Uncertainty Principle has caused a lot of debate and disagreement. However, in fact, the main problem is that the principle is sub The intense philosophical debate about the Heisenberg Uncertainty Principle derives its strength from the conclusion that there is a fundamental limit to how much we can know about the subatomic world, whether epistemological, ontological, or both. raises major philosophical issues.

In order to solve the problems under consideration, it is appropriate to evaluate the concepts of "events" - "observer" - "measurement" and their relations with each other. The subject of Heisenberg's uncertainty principle is "electron". The quantities to be measured are the "position" and "momentum" of the electron in motion. According to the uncertainty principle, to measure the motion of an electron in motion, the position and momentum of the electron are not yet known before the measurement. According to Heisenberg, measurement at the quantum level is now a phenomenon in itself. It is a phenomenon in the sense of interference or malfunction by its elements of nature.

According to Bridgman, it is determined whether an electron has a position and a velocity by measuring or deciding to measure the electron's position and velocity. The physical properties of an electron are not things that exist in its natural essence in the absolute sense, but they are properties that include the observer. That is, the measurement and the observer are inseparable, and this changes the ontological structure of the electron. . electron.

According to Rovelli, Heisenberg thought that electrons did not always exist. Electrons only exist when someone is looking at them, or more precisely, when they interact with something else. When electrons hit an object, there is a calculable probability that they appear somewhere and can be imaged. In quantum mechanics, no object has a definite position unless it collides with another object. The description of the transition of an electron from one interaction to another is carried out using an abstract formula that does not lie in real space, but in abstract mathematical space.

These jumps, which allow individual electrons to move from one interaction to another, occur randomly rather than in a predictable manner. So it is impossible to predict where the electron will appear. Only the probability can be calculated based on the location of the electron. Therefore, this condition in the Heisenberg Uncertainty Principle is not an ontological truth, and the reason for the uncertainty is that the measuring instruments are not sensitive enough. The measuring instruments in question will never be sensitive enough, since they themselves consist of electrons. With this approach, one can interpret that the "uncertainty" in question is epistemological.

However, the "uncertainty" in the Uncertainty Principle seems to be more than just an epistemological issue of what we know about nature. This situation can be interpreted as an ontological problem directly related to nature itself. The problem is not "not knowing", but "not knowing". It can be understood from these comments that the Heisenberg Uncertainty Principle cast doubt on assumptions about the unquestionable basic properties of matter. Here is Heisenberg's commentary on the matter:

- "Electrons and atoms do not have the same level of physical reality as the things in our everyday experience. "The search for an optimal physical reality for electrons and atoms is precisely what quantum mechanics is all about."

These views of Heisenberg can be interpreted as a sign that we need a new epistemology. The "uncertainty" in the Uncertainty Principle is neither a flaw in the theory nor a failure in the measurements. This is the fundamental truth of how nature behaves at the subatomic scale. In response to criticism, Planck stated the following: "The biggest accusations against theoretical physics are that it goes to abstract mathematical formalism and reality slips out from under its feet. This criticism is as unfair as it is sterilizing. Because the value of an idea is not measured by its concreteness, but by the work achieved.

With these views, Planck seems closer to instrumentalism than to scientific realism. Scientific realism asserts that objects in the world have a reality independent of human thought and perception, separate from human actions, and scientific theories can be considered true only if they follow this idea. Instead of science, Einstein argued that it gives us empirically adequate theories. , it is important to understand what this world is like. Therefore, Einstein is a scientific realist. On the other hand, Bohr, one of the founders of quantum mechanics, Heisenberg and some other scientists stated that the purpose of physical theories is only to provide a way to predict phenomena. Therefore, they are instrumentalists.

A major debate between Bohr and Einstein on this topic began at the Fifth Solvay Congress in 1927 and continued until Einstein's death in 1955. Soon after these discussions began, it became clear that quantum mechanics could be developed and was very successful in its predictions. . seen However, even today it is difficult to say that any interpretation of quantum mechanics is fully agreed upon.

Summary

In terms of its structure, organization, and operation, quantum mechanics has many remarkable properties compared to previous theories of physics. The interpretation of quantum mechanics is a philosophical issue and highly controversial. Of these interpretations of quantum mechanics, the one associated with Heisenberg's Uncertainty Principle is one of the most difficult and profound to accept. In the principles advanced by Heisenberg and his contemporaries such as Pauli and Dirac, empirical-operational approaches are distinguished as a tendency to avoid unobservable entities. Philosophically brilliant intellectual trends toward the theories of second-generation quantum physicists, especially Heisenberg, led to crises in ontology, epistemology, and especially causality.

In his Uncertainty Principle, Heisenberg tried to explain, along with causation, why causation is impossible at the subatomic scale, in terms of the limits of our observations, as in classical physics. Causality is impossible because it affects the observed object. Seen in this light, "uncertainty" appears as a reality inherent in the immediate objects themselves. For example, the existence of an electron can appear as either a particle or a wave, but not both at the same time. This is a serious ontological problem for philosophy. It seems that it is impossible to talk about the movement of particles independently of the observation process. In quantum theory, the mathematically formulated laws of nature seem to depend not on the fundamental particles themselves, but on our knowledge of them. This situation is a serious epistemological problem for philosophy.

This problem is related to the Heisenberg Uncertainty Principle of finding the precision of an observation, or the absolute limit to which we can know. This result is not a flaw or flaw in the uncertainty principle. It cannot be prevented by improving the techniques used in surveillance or increasing technological capabilities. When it comes to quantum mechanics, the boundary between epistemology and ontology seems to disappear. There is a need for an epistemological and ontological reassessment of quantum mechanics. At the subatomic scale, which shapes the modern world and has a different kind of reality, our medium-sized senses are inadequate. The Heisenberg Uncertainty Principle showed that some of Newton's assumptions about physical nature were not true. This formula shows why the concepts of Newtonian mechanics cannot take us very far, because in order to calculate a mechanical process, one needs to know the position and velocity of a particle at a given moment, and quantum theory has determined such a thing. cannot happen. Although the calculations in quantum mechanics seem complicated, the answers are still specific and understandable.

Newton's theory is not sufficient for such complex systems. Therefore, Heisenberg's work revealed the first evidence for the consistency and integrity of quantum mechanics. For almost a century, the correctness of quantum mechanics has been proven by various experiments, and there is no doubt about its validity.

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