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Research article

A Hermeneutical Analysis of Quantum Mechanics

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Abstract

The calculations and predictions of quantum mechanics have been successful, but there is a debate whether quantum mechanics is understood. Understanding quantum mechanics from a hermeneutical perspective will reveal new features of quantum mechanics. This requires first of all a review of key concepts as they are rendered in German, English, and Chinese. Interpretation [Chinese “quán shì”] in hermeneutics consists of *Erklärung* [explanation – Chinese “shuō míng”] and *Auslegung* [explication – Chinese “chǎn shì”]. The development of quantum mechanics reflects the iterative process of explication-explanation-explication-explanation. Quantum matter revealed by quantum mechanics is characterized by hermeneutics, fusion of horizons, and history of effects. This can be shown in respect to the delayed-choice experiment. Here, the “past horizon” of the photon becomes an unfinished history, a reversible quantum being, which can only be transformed into a classical existence through quantum measurement. A contemporary photon's “past” reality and “present” reality will be overlaid and fused to form the photon's “whole” reality. This is the photonic reality, and it involves a superimposed horizon that forms the whole of the total effect. This hermeneutic interpretation sheds light not only on the interpretation of quantum mechanics but also on the question why there are several such interpretations with a tendency for more to come. In short, the intertwining of explication and explanation, and the projection of meaning reveal that quantum mechanics is hermeneutic.

Keywords: Hermeneutics; Quantum matter; Horizon fusion; Effective history

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Научная статья

Герменевтический анализ квантовой механики

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Аннотация
Расчеты и предвидение квантовой механики оказались успешными, но ведутся споры о том, понимают ли квантовую механику. Понимание квантовой механики с герменевтической точки зрения открывает новые особенности квантовой механики. Что требует, прежде всего, анализа ключевых понятий в том виде, в каком они представлены на немецком, английском и китайском языках. Интерпретация [английское “interpretation”, китайское “цюань ши”] в герменевтике состоит из объяснения [немецкое “Erklärung”, английское “explanation”, китайское “шу мин”] и экспликации [немецкое “Auslegung”, английское “explication”, китайское “цюнь ши”]. Развитие квантовой механики отражает итеративный процесс экспликации-объяснения-экспликации-объяснения. Квантовая материя, открытая квантовой механикой, характеризуется герменевтикой, слиянием горизонтов и историей эффектов. Это можно продемонстрировать на примере эксперимента с отложенным выбором. Здесь “горизонт прошлого” фотона становится незавершенной историей, обратимым квантовым существом, которое можно преобразовать в классическое существование только посредством квантового измерения. “Прошлая” реальность современного фотона и “настоящая” реальность будут накладываться и сливаться, образуя “целую” реальность фотона. Это фотонная реальность, и она включает в себя наложенный горизонт, который формирует весь общий эффект. Эта герменевтическая интерпретация проливает свет не только на интерпретацию квантовой механики, но и на вопрос, почему существует несколько таких интерпретаций с тенденцией к появлению новых. Вкратце, переплетение экспликации и объяснения, а также проекция смысла показывают, что квантовая механика герменевтична.

Ключевые слова: Герменевтика; Квантовая материя; Слияние горизонтов; Эффективная история

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INTRODUCTION

Quantum mechanics has been a great success, however, there are many debates and difficulties in understanding quantum mechanics. From the early development of quantum mechanics to contemporary times, a variety of interpretations of quantum mechanics have emerged. Some physicists have recognized that clarifying the concepts of quantum mechanical interpretations not only solves problems of scientific understanding, but also prevents the development of quantum technology from going astray. However, researchers of quantum mechanics have not paid much attention to the study of quantum mechanics and its contemporary development from a hermeneutic perspective. In hermeneutics, there are many debates about the meaning of “interpretation” and related terms such as the notion of hermeneutics itself. In this paper, we will discuss the meanings of interpretation, hermeneutics, and related terms, and then explore the roles of interpretation, explanation, and explication in quantum mechanics, to reveal the structure and characteristics of quantum hermeneutics, and to provide a possible way forward for the correct understanding of quantum mechanics.

MEANING OF HERMENEUTICS AND ITS RELATED TERMS

Hermeneutics is the Greek word *Hermeneutike*, Latin *hermeneutica*, German *Hermeneutik*, which are derived from Hermes. In Greek mythology, Hermes was a messenger of the gods, charged to carry their will to earth. The work he did involved original meaning, translation, skill, and persuasion.

There are certain hermeneutic ideas in ancient China. Objectively speaking, Chinese hermeneutics is still in an early stage, and has not yet opened up a new way in hermeneutics.

Western hermeneutics can be traced back to the “Peri hermeneias” of Aristotle's Theory of Instruments in ancient Greece. The “Peri hermeneias” is not very extensive, mainly discussing the definitions of nouns, verbs, etc., and explaining the meaning of negation, affirmation, propositions and sentences, as well as the relationship between them. The “Peri hermeneias” does not yet cover many of the topics later pioneered by hermeneutics, such as the author's original meaning, the original meaning of the text, the meaning received by the reader, the hermeneutic circle, and so on.

The object of study of hermeneutics has shifted from canonical texts, to text in general text, and then to *Dasein*, and the trend is that it will turn to nature (including the classical world and the quantum world). Its study includes not only the study and understanding of text, the meaning of text, but also the study of methodology, ontology and epistemology of textual understanding, as well as the question of how an understanding of text is possible. And finally, hermeneutics involves the wisdom of practice.

Hermeneutik has been defined by a number of not only Western scholars. Martin Heidegger (1927/2010) wrote in *Being and Time*:

> [W]e shall see that the methodological meaning of phenomenological description is *interpretation*. The λόγος [logos] of the phenomenology of Dasein has the

> character of ἑρμηνευτική [hermeneutik], through which the proper meaning of being and the basic structures of the very being of Dasein are *made known* to the understanding of being that belongs to Dasein itself. Phenomenology of Dasein is *hermeneutics* in the original signification of that word, which designates the work of interpretation. (p. 35)

This reflects questions of ontology and methodology. According to Paul Ricoeur (1973): "Hermeneutics is the theory of the operation of understanding in its relations to the interpretation of texts" (p. 112). It can be seen that methodology has always been the core concern of hermeneutics.

Defining hermeneutics is controversial. From the perspective of the history of hermeneutics and its contemporary manifestation, the German version of Wikipedia's definition of hermeneutics is very concise and to the point: Hermeneutics (*Hermeneutik*) is the theory of interpretation of text and understanding. The definition of hermeneutics directly points out the object of study of text and understanding, and the core of hermeneutics is the German word *Interpretation*.

According to the German dictionary *Wahrig Deutsches Wörterbuch*, the meaning of *Interpretation* is: *Erklärung, Auslegung, Deutung* [explanation, exegesis or explication, construal]. This meaning of *Interpretation* can be translated into Chinese as „诠释 (quán shì)." The English equivalent of the German concept *Interpretation* is „interpretation." According to the English *Merriam-Webster* online dictionary, the main meanings of „interpretation" are: (1) the act or the result of interpreting : explanation; (2) a particular adaptation or version of a work, method, or style; (3) a teaching technique that combines factual with stimulating explanatory information. It is clear that the English word interpretation emphasizes meaning, but does not have the richer content of the German word *Interpretation*.

On the view to be developed here, *Erklärung* [explanation] emphasizes causality and elaborates reasons and causes. It can be translated into Chinese as „说明 (shuō míng)." *Auslegung* [exegesis or explication] does not emphasize causality and focuses on the interpretation of texts or events in general, and the scope of *Auslegung* is wider than that of *Erklärung*. *Auslegung* has a unique place in hermeneutics, and was first used by Wilhelm Dilthey to generalize the understanding of the *Geisteswissenschaften* or humanities, that is, the understanding of the manifestations of life as being in accordance with technology and art. He writes, "*Die Natur erklären wir, das Seelenleben verstehen wir* [Nature is what we explain and the life of the mind is what we understand]" (Dilthey, 1964, p. 144). The second passage by Dilthey reads, "*Das kunstmässige Verstehen dauernd fixierter Lebensäusserungen nennen wir Auslegung* [We call exegesis the artful understanding of permanently fixed expressions of life]" (Gadamer & Boehm, 1976, p. 126). It agrees with general philosophical practice to translate „erklären" in the first quote as "explain,", while *Auslegung* in the second quote is best translated as "exegesis" or, more commonly, "explication."

The Chinese scholar Hong Handing agrees that, according to German scholars, „interpretation" has at least two meanings: *Erklärung* and *Auslegung*. *Erklärung* focuses on illustrative and descriptive interpretation in terms of principles or wholes, while

Auslegung favors elucidative and revealing interpretation in terms of the things themselves, which we can translate as "explication."

The German *Interpretation* is translated directly into English as "interpretation", while *Erklärung* is translated into English as "explanation" ["说明 or shuō míng "], and Auslegung is translated into English as „explication" ["阐释 or chǎn shì"]. After the examination of the Chinese language, the meaning of Chinese "interpretation" (quán shì) should be: i) with the help of language, technology, people, and in accordance with the nature of things to justly, normatively, lawfully understand, explain, state reasons; ii) with the help of technology and according to laws, norms, fairness, or goodness, to open, understand, explain, or state reasons for things. The meaning of "explication" (chǎn shì) in Chinese also has two basic aspects: i) to express the gradual unfolding of things from the hidden to the obvious by virtue of one's own ability; and ii) to bring out the broad and far-reaching meaning of things by virtue of one's own ability (Wu, 2022, p. 93-95).

The Chinese word "quán shì" (interpretation) is included in the *Hànyǔ Dà Cídiǎn* [Chinese Big Dictionary]. The meaning of the Chinese word "shuō míng" (explanation) in that dictionary is: 1) description and understanding, 2) proof. From the terminological point of view, "shuō míng" (explanation) primarily highlights the meaning of causality.

It should be noted that the English translations in terms of explanation and explication are less precise, while the German and Chinese terms are more precise. In this paper, "explanation" emphasizes the meanings of proof and causation, while „explication" emphasizes the aspect of revealing a nature or hidden meaning. The English word "explanation" corresponds to the Chinese words "explanation" (shuō míng), "elucidation" (Jiěshì) and "explication" (chǎnshì). Chinese "explanation" (shuō míng) focuses more on causal relationships and has the meaning of proof; Chinese "elucidation" (Jiě shì) is more broad and general, as long as a certain account is given; Chinese "explication" (chǎn shì) is to disclose the thing from the hidden to the obvious. In short, we will compare the translations of three words as follows:

German, Chinese, English

Interpretation, quán shì, interpretation

Erklärung, shuō míng, explanation

Auslegung, chǎn shì, explication

"Interpretation" and "hermeneutics" are closely related in that the translation of „interpretation" involves not only the humanities, but also the development of hermeneutics as a whole, the natural sciences and technology. The humanities emphasize understanding, as do the natural sciences and technology.

Since the modern scientific revolution, the positive nature and validity of the natural sciences have posed a serious challenge to the humanities; do the humanities have the same scientific nature and validity as the natural sciences? In German, *Geisteswissenschaft* [humanities] is the counterpart of *Naturwissenschaft* [natural science]. In order to ground *Geisteswissenschaft* and distinguish it from natural science, Dilthey argues that the difference between the methods of natural science and *Geisteswissenschaft* is between explanation (*Erklärung*) and understanding (*Verstehen*). "Explanation" is the subsumption of individual instances, such as observations and experiments, under general laws, and employs the method of causal explanation. Understanding, on the other hand, is to enter into the inner life of others through one's own inner experience, that is, into the world of the human spirit. In other words, *Geisteswissenschaft* provides an "understanding" of the world which differs from the causal explanation of natural science.

Can't the natural sciences use hermeneutic methods? The famous philosopher of science, Karl Popper, disagreed with Dilthey's limitation of hermeneutics to the humanities alone. He argued that human knowledge of things is an explanation or explanatory hypothesis, that it is also possible to err, and that observation is permeated by theory. Understanding is the aim of the humanities as well as the natural sciences. He said: "I oppose the attempt to proclaim the method of understanding as the characteristic of the humanities, the mark by which we may distinguish them from the natural sciences." (Popper, 1979, p. 185).

Transformed by Heidegger and Gadamer, hermeneutics focuses not only on the text but, more importantly, on being. Since hermeneutics is the state of being itself displayed, the display also of the state of being of the objects of the natural sciences (e.g., micro-objects) is a kind of hermeneutics.

As Patrick Heelan (1994) said in his phenomenological study of quantum mechanics, hermeneutics has become a "strong hermeneutics" pointing to experience or practice, instead of a "weak hermeneutics" pointing to the narrow textual material (pp. 363-373). Don Ihde (2009), the founder of post-phenomenology, argued:

> The natural sciences also are deeply hermeneutical, and, on the other side, the unique hermeneutic techniques developed in the natural sciences have deep implications for the human and social sciences. (p. 64)

Generally speaking, written texts are considered the standard texts of hermeneutics, and images, sculptures, etc. are regarded as "paratexts", but in Ihde's view, material hermeneutics, which is part of the natural sciences due to the role of technology, goes beyond textual hermeneutics in the production of objective knowledge and the advancement of disciplines such as anthropology, history, and archaeology.

At present, hermeneutics mainly interprets classical, macroscopic texts (things). There are not many interpretations of the quantum world (quantum texts). While Zhiping Cao (2016) provided a more comprehensive account of Western scientific hermeneutics, his hermeneutical study of the quantum world has yet to be developed.

Since hermeneutics is a method of universal significance, it can interpret macro humanistic phenomena and also phenomena of natural science, and thus it should interpret classical phenomena as well as quantum phenomena so that people can better understand and utilize quantum phenomena and quantum world.

In fact, quantum mechanics has raised a very important problem regarding the interpretation of quantum mechanics. The interpretation of quantum mechanics is not only an external explanation of the quantum world, but also an internal explanation of the quantum world itself (including causal explanations of the quantum world). According to Heelan, quantum mechanics can be interpreted as a bridge between the physical and social sciences. In the spirit of Niels Bohr and Werner Heisenberg, he says, the physical objects in quantum mechanics are revealed as being within the process of measurement in a definite domain, socially and historically. The hermeneutic character of quantum mechanical measurements reveals close parallels to the social/historical science of hermeneutics. The hermeneutic analysis of science requires a shift from an epistemological to an ontological attitude (Heelan, 1995, p. 127).

The development of quantum mechanics reveals the importance of interpretation. A set of quantum mechanical concepts and corresponding laws constitute a quantum mechanical interpretation such that, at present, quantum mechanics involves more than 10 different interpretations, such as the Copenhagen interpretation or multi-world interpretation. Max Jammer's famous book "The Philosophy of Quantum Mechanics" features the subtitle "the interpretation of quantum mechanics in historical perspective." This work is a comprehensive introduction to the problem of interpretation of quantum mechanics. It compares the relationship between each major interpretation of quantum mechanics and various concepts, the similarities and differences between the various interpretations and the answers given by leading scientists to some basic questions in the interpretation of quantum mechanics, and the differences between the various interpretations in terms of basic epistemological questions; and finally lists the various objections to each interpretation so that the reader can judge for himself or herself. Choosing a theory of quantum mechanics is not only a process of acquiring the scientific laws of the quantum world, but also a question of how to choose and weigh them. For example, for a specific quantum mechanical problem, it is a matter of choice and trade-off as to which interpretation of quantum mechanics to adopt to deal with the problem.

The foregoing analysis shows that the meaning of the German word *Interpretation* in hermeneutics includes *Erklärung* (explanation) and *Auslegung* (explication), and that the Chinese word "诠释 (quán shì)" also includes both the meanings of "说明 (shuō míng, explanation)" and "阐释 (chǎn shì, explication)." The development of quantum mechanics will show that explication and explanation display the structure of the meaning of interpretation.

INTERPRETATION, EXPLICATION AND MEANING-PROJECTION IN QUANTUM MECHANICS

Natural science requires concepts as a prerequisite. Natural science needs to be based on a set of concepts, and these concepts are part of a certain history and culture. The concepts accepted by the scientific community are not necessarily accepted by non-community members, which requires the use of hermeneutic skills to make non-community members accept them. For this reason, Thomas Kuhn (2000) called these concepts of science its "hermeneutic basis," that is, its "paradigm" (p. 221). Kuhn (2000) states,

> My argument has so far been that the natural sciences of any period are grounded in a set of concepts that the current generation of practitioners inherit from their immediate predecessors. That set of concepts is a historical product, embedded in the culture to which current practitioners are initiated by training, and it is

> accessible to nonmembers only through the hermeneutic techniques by which historians and anthropologists come to understand other modes of thought. Sometimes I have spoken of it as the hermeneutic basis for the science of a particular period, and you may note that it bears a considerable resemblance to one of the senses of what I once called a paradigm. (p. 221)

With the hermeneutic basis of paradigms, scientists need only do conventional scientific research, i.e., solve specific scientific problems according to paradigms.

Kuhn (2000) also states that "[t]he natural sciences, therefore, though they may require what I have called a hermeneutic base, are not themselves hermeneutic enterprises" (p. 222). According to Kuhn and in terms of the evolution of science, there is often a scientific crisis, a scientific revolution, and then normal science. In the stage of scientific crisis, there are many phenomena that cannot be explained by the original scientific theories, and scientists lose confidence in the existing scientific concepts and scientific laws, so people begin to doubt the original scientific paradigm and try to put forward new concepts or new laws to explain the phenomena that occur.

Once a new concept or a new law accounts for key abnormal phenomena and is accepted by other scientists, this is when a scientific revolution occurs and a new scientific paradigm is formed. Obviously, in the stage of scientific crisis and scientific revolution, a variety of concepts, even bizarre concepts, are produced. Supported by some experimental evidence, some theoretical arguments, etc. the scientists who put forward these concepts need to persuade, other scholars to accept their viewpoints, and this activity is carried out until the formation of a new scientific paradigm. Undoubtedly, at the stage of scientific crisis and revolution a hermeneutic process of explanation and explication takes place, in which certain techniques (including even exaggerations of the significance of arguments) are used to persuade others on the basis of scientific, philosophical, and so on, "grounds."

At the stage of normal science where scientific theories have been accepted by scientists, is normal science just about doing specific calculations?

As a matter of fact, the basic meaning and reference significance of scientific concepts, laws of science, etc., are not elucidated during normal science, nor is it clear what the scope of application of these concepts and laws is. The so-called basic meaning of a concept or law refers to the basic meaning of the concept or law itself as expressed in science. The so-called reference meaning of a concept or law means what the concept or law refers to in science, what entity, relationship or structure it represents, and what kind of relationship it has with the objective world, revealing its direct scientific significance.

For example, after Newtonian mechanics was established in the 17th century, the concepts of force, mass, inertia, time, space, speed, acceleration, etc. were not clear and there was a process of acceptance, and the scope of application of Newtonian mechanics was being explored. Take the concept of mass as an example. Newton's 1687/2021 definition of mass is: "The quantity of matter is the measure of the same, arising from its density and bulk conjointly" (p. 1). Obviously, this definition does not give a clear definition of mass; in fact, studies in electromagnetism and quantum mechanics have shown that matter has a variety of quantities, such as charge, spin, baryon number, and so on. To what extent Newtonian mechanics is applicable, first, it is necessary to see whether Newton's laws are correct in order to judge when they are applied; second, it is necessary for new physical theories (e.g., relativity, quantum mechanics, etc.) to give the scope of application of the old theories; and third, it is necessary for extensive scientific communication (scientific description and scientific interpretation) and hermeneutical techniques (e.g., explication). It can be seen that during normal science, science is not just a work of applying science and solving difficult problems, which belongs only to explanation; at the same time, how to understand the concepts, laws of scientific theories, their precise meanings, reference significance, adaptive scope, and deeper social and cultural significance, etc., still need to be explored in depth, which belongs to explication; therefore, during normal science, the explanation of scientific theories is combined with explication, which is a hermeneutic activity or process (compare Liu, 2024).

In the founding stages of quantum mechanics, explanation and explication were complementary and alternating. One example is the introduction of the concept of energy quanta. At the end of the 19th century, blackbody radiation had accumulated empirical data at short and long waves with the discovery of Wien's law and Rayleigh’s law, respectively. Max Planck cobbled together a mathematical formula – Planck's law of radiation – based on these two laws, on the basis of which he came up with the concept of energy quanta, i.e., that energy is not continuous but has a minimum unit of energy (Wu, 2016, p. 1-3).

Planck creatively introduced the concept of energy quanta through a cobbled-together mathematical formula, which involved a process of explication, as the concept of energy quanta opened up the new science, quantum theory, of which he became the founder. However, it is because Planck's radiation law is “cobbled-together,” one has been looking for how to deductively derive Planck's radiation law from general scientific theories (including electromagnetism, thermodynamics, statistical physics, etc.), which is a process of pursuing explanation. The concept of energy quanta – including the concept of “light quanta,” later proposed by Albert Einstein, – formed the “quantum” concept of quantum mechanics, where the correctness of the quantum concept is established through the subsequent establishment of quantum mechanics and its experimental test.

In the normal scientific stage of quantum mechanics, the same hermeneutic activity takes place. In classical science, the form of scientific concepts and laws is basically determined, and hermeneutic activities are mainly manifested in how to understand the basic meaning of scientific concepts and laws, their reference and contextual significance. At the stage of quantum mechanics, the basic concepts and laws of quantum mechanics are changing, as is the formation of different groups. Each group of scientific concepts and scientific laws constitutes an interpretation of quantum mechanics. Healey (1989) defines the interpretation of quantum mechanics as a description of what the world will be like when quantum mechanics is true (p. 6).

There are more than 10 prevailing interpretations of quantum mechanics. Each interpretation of quantum mechanics is a theory of physics for understanding the quantum world, with both a conceptual and a mathematical framework. They are new ways of describing quantum mechanics, and they all describe the quantum world from different sides, levels, or perspectives.

Unlike the classical world, which can be perceived directly by the human senses, the quantum world always requires a process of gradual disclosure, a gradual change from the potential to the apparent. It is a gradual change from the potential to the manifest. The gradual disclosure of the quantum world to human beings is an explication. From the initial revelation of experiments or conceptual thinking to the process of discovering the laws of quantum mechanics, this is a process of explication and a process of scientific discovery. When the laws of the quantum world were discovered, people carried out scientific calculations and predictions under the laws of quantum mechanics, which is an explanation process, however, in this process of explanation, it is not that the concepts and laws of quantum mechanics are all completely shown and clearly understood by people, in which certain basic concepts and laws of quantum mechanics still need to be explored more deeply, which is an explication that includes the exploration of the quantum the world itself. Time, space, matter, and other ontological presuppositions need to be carefully clarified. Through such explication, people will get a clearer understanding, but also may obtain new quantum laws that will allow for new scientific predictions, which is again explanation. With the development of quantum theory, the original thought of clear understanding was later found to be insufficient, and then produced a new understanding, which is a process of explication.

It can be seen that in the process of the development of quantum theory, explanation → explication → explanation → explication → ...... is a process of constant alternation.

A basic difference between explanation and explication is that when the laws of things are discovered, people utilize the laws and concepts for scientific calculations or scientific prediction, which belongs to "explanation." Things or concepts move from unclear to becoming clearer, from uncertainty to certainty, this is "explication." Having created the concept or discovered the law that was originally thought to be clear, it is found after further exploration that there is a deeper meaning and significance, this is also "explication."

There are many interpretations of quantum mechanics, and there is a tendency for their number to increase, which is rooted in several reasons. First, there is formalization. In the creation of quantum mechanics, a formal system (i.e., a mathematical form or law) always comes first, but what exactly that formal system expresses is not clear, nor is the meaning of the physical quantities in it, and yet the formal system supersedes its explication and explanation.

Second, the role of the observer is unclear. The observer has different roles in various interpretations of quantum mechanics. In the Copenhagen interpretation, the many-minds interpretation, and the self-consistent historical interpretation, the observer plays an important role. The Copenhagen interpretation holds that the wave function comes to be described to represent all that an observer can know about a quantum system. The hidden-variable interpretation, and the many-worlds interpretation argue that observers do not play a role in quantum measurements.

Third, the meaning of probability is unclear. In the quantum world, it is the probability amplitude (wave function) that describes wave nature, and the iteration of the probability amplitude is the iteration of the wave, which in this case is a wave of quantum nature. The square of the absolute value of the probability amplitude (wave function) corresponds to classical probability. Is the classical probability here a propensity, a frequency, or a subjective expectation? The formalization of the theory, the notion of the observer, and the probability characteristic of the theory are three reasons for the proliferation of interpretations – a point made by Omnes (1999).

On the view developed here, there are four further reasons why a quantum mechanical interpretation is needed. Fourth, the meaning of the wave function (probability amplitude) is not clear. At the beginning of the creation of Erwin Schrödinger's fluctuation equation, he linked the parent function S with the unknown function by connecting it with the Hamilton-Jacobi equation and assumed $S = log\,\psi$. The meaning of the unknown function was not clear at that time, and it was later named the wave function. Schrödinger called ψ a “mechanical field scalar” and proposed an electromagnetic interpretation of the wave function ψ. Obviously, these ideas were exploratory. Is the wave function an instrumental mathematical description, or a real description of the quantum world? As Changpu Sun (2017) argues, there is no consensus so far on the quantum mechanical interpretation (p. 481) – understanding how the wave function describes the microscopic world – with the author of the present paper arguing that the wave function is a relatively structural reality (Wu, 2012, pp. 118-120).

Fifth, there is the uncertainty of the quantum world itself. On the one hand, the quantum world itself as revealed by the uncertainty principle has uncertainty, so there is uncertainty of the quantum object, as different technical conditions will produce a different nature: An instrument with a fluctuating nature produces quantum phenomena of a fluctuating nature, and an instrument with a particulate nature produces quantum phenomena of a particulate nature – which is wave-particle duality. So, on the other hand, is there only one quantum world, or are there multiple versions? Different quantum mechanical interpretations offer different views. The many-worlds interpretation holds that there is one wave function and many worlds. Thus, multiple concepts and theoretical systems are needed to grasp an uncertain quantum world.

Sixth, the role of the author, that is, of the founders of quantum-mechanical interpretations is not clear. The reason why there are different interpretations of quantum mechanics lies in the fact that there are different founders of quantum mechanics, and these authors have different projects of sense-making that produce different interpretations of quantum mechanics.

Although relativistic theories also have forms that precede explication and explanation, there is only one physical world of relativity. In contrast, the founders of quantum mechanical interpretations can construct completely different quantum worlds, even of a kind that defies people's intuitions, such as the many-worlds interpretation, the many-minds interpretation, and so on. It depends on the intention of the modeler whether or not the indeterminate quantum world is like a lump of clay that one can knead as much as one wants. It is the consciousness, intention or intent of the different founders of quantum mechanics to devise the meaning of the quantum world first, in order to promote the clarification or enlightenment of different quantum worlds. Here, sense-making is a kind of prior mastery of the quantum world, providing a basic blueprint of the structure of the quantum world and its interrelationships. Of course, the correctness of this project of sense-making must be tested by subsequent quantum experiments.

Seventh, the role of users is unclear, that is of scientists who use quantum mechanical interpretations, etc. How are they to choose between multiple quantum mechanical interpretations? There are no set criteria. Between different interpretations of quantum mechanics, there are problems of interpretation.

For each quantum mechanical interpretation it holds that explanation → explication → explanation → explication → .... The creative discovery of an equation (law) of quantum mechanics based on a certain premise is explication; and then, on that basis, the equation is used to anticipate a certain quantum experience, which involves explanation.

To have a project is to be conscious of a possible plan or design for a future thing or event. Planning confronts a world of future possibilities. It is possible to be right, and it is possible to be wrong. Projecting is prior to meaning in that it plans for sense-making. In different interpretations of quantum mechanics, each of the proposers of that quantum theory has different assumptions for sense-making, and it is human planning that is at work in advance and that is planning for meaning. For example, the many-worlds interpretation and the many-minds interpretation, etc., have different assumptions about the quantum world and consciousness.

There is also the problem of explication in respect to different interpretations of quantum mechanics. The same concept is explicated in different interpretations of quantum mechanics to make the meaning of that concept clearer. Thus, the elaboration of concepts, laws, etc., in multiple quantum mechanical interpretations is an understanding of multiple aspects of the quantum world. The existence and development of multiple interpretations of quantum mechanics reveals that explanation and explication are combined, and it reveals the intention or projection of the meaning of the founder of some interpretation of quantum mechanics. In short, the intertwining of explication and explanation, and the projection of meaning reveal that quantum mechanics is hermeneutic.

INTERPRETIVE NATURE, HORIZON FUSION, AND EFFECTIVE HISTORY OF QUANTUM MATTER

Quantum mechanics reveals remarkable features that are different from those of classical science, especially the fact that quantum matter is characterized by its interpretive nature or hermeneuticity, by a fusion of horizons, and by its history of effects.

The interpretive nature of quantum matter

Quantum matter is always subject to the interpretation of quantum theory and quantum technology, and so quantum matter reveals different states or properties.

According to Heelan (1998), The lifeworld has a furniture that comprises those physical and embodied cultural objects, both ‘natural’, like trees, and ‘cultural’, like institutions or technologies, which have names or descriptions in the language; among them are perceptual objects. All of these are (to use Heidegger’s term) *ontic beings*.” (p. 281). In terms of their field of study, the humanities and social sciences study the world (social, spiritual) as it relates to human beings, whereas the natural sciences are confronted with unknown features of the natural world that need to be explored.

Don Ihde, the founder of post-phenomenology provides an in-depth study of the relationship between human beings, technology, and the world, and he proposed four kinds of relation: the embodied relation, the hermeneutic relation, the background relation and the alterity relation. His hermeneutic relation is expressed by the intentional formula: human → (technology-world) (Ihde, 1979, pp. 4-6). Hermeneutic relations show that there is a need for hermeneutic transformation of technology between human experience and the world, with technology becoming part of the world. The quantum world and human beings are interpreted through technology, but human beings cannot grasp quantum technology directly, which needs to be converted with the help of classical technology. Guolin Wu's (2016) research shows that the intentional formula of quantum technology can be rewritten as follows: human → (classical technology – quantum technology – microcosm) and the "microcosm" in this model is the quantum world (p 312). Obviously, the relationship of the quantum world to human beings should be expressed by "interpretation."

Ihde chose hermeneutic relations to describe the hermeneutic role of technology in mediating between humans and the world. It is clear that technology provides the hermeneutic of a (quantum) world that must be true, not false, a manifestation of the quantum world as it is. For the real manifestation of the quantum world, it is necessary not only that it is preceded by a theory (including concepts) of quantum mechanics, but also that one is able to successfully create quantum technological artifacts (quantum instruments) that are based on this theory of quantum mechanics.

Ihde (2009) puts forward "material hermeneutics" for the understanding of natural substances (p. 63). For people based on different theories and technical means, the same substance may make "different" sounds or present different states, so that people can hear or see the phenomena that could not be understood before. In this way, the hidden states of natural substances are revealed continuously. For example, the observation of stars through ordinary astronomical telescopes that can see the size, color, shape of the stars, was followed by the emergence of spectroscopy, so that scientists can use the spectra of the stars to determine their surface temperature. It can be seen that with the progress of observational technologies people's understanding of the stars has become more and more in-depth and comprehensive. Therefore, the interpretation of the material text is closely related to what kind of theory people adopt and what kind of technology they use. Scientific theory and technology are important means of interpreting matter. As Gadamer (2004) put it, "It is enough to say that we understand in a different way, if we understand at all." (p. 296). In addition, the autonomy of the material text is also reflected in the effective historical nature of scientists' understanding of the material text: that is, the constant turnover and evolution of the theories of the natural sciences, their specific scientific tradition, social environment, epistemic interest and analytic mind-set determines the historical nature of scientists' understanding of natural matter.

With the deeper study of the quantum world, it has been found that microscopic particles (electrons, photons) exhibit phenomena different from those of macroscopic objects. At the ontological level, the quantum (microscopic object) itself can be regarded as a wave function, while the quantum state (property) described by the wave function is a possible state, and the quantum state we measure is the result of the interaction between the quantum and the external environment. From a philosophical perspective of science, as far as individual wave functions or the overall wave function formed by multiple wave functions are concerned, they are real and have a rich structure. This means that the wave function must necessarily be associated with the corresponding entity, and it is said that a certain wave function actually corresponds to a certain microscopic object. The wave function of a photon, for example, corresponds to the photon entity. The wave function with reality is similar to macroscopic matter with "divisibility," which is because the wave function can be decomposed into different complete basis vectors, and it may then be expanded into different complete sets of basis vectors (sub-wave functions), that is, a quantum state can be decomposed into several different sub-states.

The "divisibility" of the wave function reveals that the quantum state is a possible state, and that the specific properties of the quantum system can change under different conditions of the measurement device. The properties of microscopic particles in the quantum world change depending on the quantum theory and measurement device used by the measurer (interpreter).

Horizon Fusion of Quantum Matter

Let us examine John Archibald Wheeler's famous delayed-choice experiment, see Fig. 1. Suppose that a photon of light is emitted from a source S and directed to a beam splitter H1, which is then divided equally into two beams of light, 2a and 2b, which pass through two mirrors, A and B, so that the two rays of light can intersect at C (the second beam splitter H2). (1) When the beam splitter H2 is not inserted at C (shown by the dotted line in Fig. 1), the detectors R1, R2 are able to determine whether the photons are coming from the path B or from A, which indicates that the light has a particle nature. 2) When H2 is inserted at C, the detector is able to conclude that a photon is traveling *both* paths B and A *at the same time*, which indicates that light has wave nature. Various delayed-choice experiments were successfully conducted to test this. The original version of the experiment was realized using fast electrons (Jacques et al., 2007; 2008).

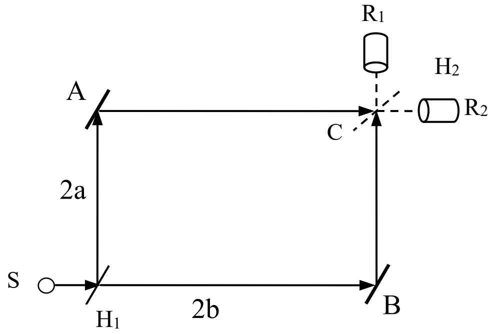

Figure 1. Experimental setup for delayed-choice

If we load the entire experimental setup at once, that is, if we decide to insert or not to insert the second beam splitter before conducting the experiment, what the experiment will show is the fluctuating or particle nature of the photon, respectively. However, Wheeler proposes that after the photon has already passed through the first beam splitter

H1 and before reaching the second beam splitter H2, one then decides whether or not to insert the second beam splitter H2, which is the core of the delayed-choice experiment. After the photon has passed through the first beam splitter, the nature of the light has already been decided, and its nature should not be affected by the change in the experimental setup later (insertion or non-insertion of the second beam splitter).

Now the delayed selection experiment is saying that even after the light has passed through the first beam splitter, i.e., the photon has been selected, we can still select the light to behave as a wave or a particle by choosing to insert or not to insert a second beam splitter, which is what Wheeler called “the present will influence the past.”

The question now is, does the experiment really show that “the present will determine the past”?

The delayed-choice experiment was designed on the basis of the laws and principles of quantum mechanics, which belongs to explanation and the study of the causal relationship between the quantum world and quantum phenomena. Explanation here consists in revealing the whats and whys of the quantum world and of quantum phenomena. Wheeler and others consciously designed the delayed-choice experiment to more deeply understand the laws and principles of quantum mechanics (which belongs to explication). The experiment also highlights the significance of Wheeler and other proposers of the projection, so as to test the nature of the microscopic particles through quantum experiments. It can be seen that Wheeler's delayed-choice experiment allows for the unification of explanation, explication, and meaning projection.

Indeed, this experiment will reveal that quantum matter involves the fusion of horizons. According to Gadamer, the horizon is the region of vision that encompasses and embraces all that is seen from a given foothold. Thus, in this experiment, “horizon” can be defined as “the area through which light passes.” The horizon is everything that can be seen from a certain foothold.

The light passing through the first beam splitter (H1 in Fig. 1) is fitted into the past horizon, which can be summarized as: past light + fixed measurement device → past horizon, where “fixed measurement device” refers to H1 and its related devices (including the light path). The past horizon formed by the first beam splitter is actually a reversible quantum world.

At the end of the detector, the light passes through the second beam splitter to form the present horizon, which can be summarized as: present light + changing measurement device → present horizon, where “changing measurement device” refers to whether H2 is inserted or not and its related devices (including the light path). The “present horizon” is the area formed by the present light through the changing device (the insertion or removal of the second beam splitter). The present field of view formed by the insertion or non-insertion of the second beam splitter is actually an irreversible classical world.

The existence of microscopic particles is formed by the “superposition” of the above two horizons.

(past light + fixed measuring device) + (present light + variable measuring device) → (past horizon + present horizon)

The above equation can be simplified as:

Light + delayed choice of measuring device → whole horizon → horizon in the wave or particle state → result of classical measurement (wave *or* particle nature)

The horizon of the past and the horizon of the present are formed into a whole horizon. Light in the past is an unfinished light, and it cannot simply be said that light in the past has wave or particle nature. Light is open, and until classical measurements are completed, it cannot be said what classical properties (wave or particle) it has. In delayed choice experiments, the fusion of the past horizon with the present horizon produces a classical measurement of a different nature.

For the delayed-choice experiment, Wheeler also suggested that "the present will affect the past," saying, "In this sense, we have a strange inversion of the normal order of time. Now we have the right to say that moving the mirror in or out has an unavoidable effect on the already past history of the photon." He adds, " 'Past' is just a theoretical word. In reality, there is no 'past' that exists unless it is recorded in the present. The kind of quantum device we use to place this point in the present will have an undeniable effect on what we call the 'past'" (Fang, 1982, p. 13). In terms of the fusion of horizons, the fusion of the present horizon with the past horizon does not mean that the present horizon participates in the past horizon, but rather that the present horizon is connected to the past horizon by way of an iterative nature and without a clear demarcation region, ultimately connecting with the classical measuring device to realize the irreversible measurement of light. The past horizon is indeterminate, and the determinism of the present horizon makes the past horizon determinate, thus making the whole horizon determinate.

There is an ambiguous space between the beam splitters H1 and H2, which is what Wheeler calls the "dragon" whose "head" and "tail" are clear and whose center is unclear, which indicates that: This ambiguous space is the region where the two horizons overlap, and there is uncertainty. But away from this iterative region, "past" and "present" are still clear.

Effective History of Quantum Matter

Delayed choice experiments show that the photon is not a classical particle, nor is it a classical wave, the photon is an unfinished quantum being, it is not a fixed classical being, and the photon is characterized by an effect history.

The effective history is an important feature of hermeneutics, as Gadamer (2004) says:

> The true historical object is not an object at all, but the unity of the one and the other, a relationship that constitutes both the reality of history and the reality of historical understanding.46 A hermeneutics adequate to the subject matter would have to demonstrate the reality and efficacy of history within understanding itself. I shall refer to this as 'history of effect'. Understanding is, essentially, a historically effected event. (p. 299)

For Gadamer, history is not nothingness, not a fixed object, but a reality revealed in relation.

Suppose we set a point *x* (not labeled in Fig. 1) anywhere on the light path between H1 and H2 of Fig. 1 (the reciprocal point of the 2a and 2b light paths), can we then say that the photon's past has been decided once the photon reaches the point x? Obviously not. Because until the photon is converted into a classical being (i.e., after the photon has not passed through H2), light is reversible and does not exist in a classical manner, but in a quantum state. That is, the past horizon is reversible and not fixed; the present horizon has classical determinism due to quantum measurements. Thus, as the past horizon and the present horizon expand and intermingle, there is a region of overlap between them. In this region of overlap, the past and present horizons intermingle to form part of the overall horizon, and it is in the region of overlap that the present changes the past and transforms the reversibility of the past into irreversibility, thus making the entire domain of vision deterministic. In other words, the being of the photon at H1 depends on the being of the photon at H2, and similarly, the being of the photon at H2 depends on the being of the photon at H1. The expression “the present will influence the past” is one-sided; the correct expression is: “the present and the past together influence (the nature of things).”

In the delayed choice experiment, the “past horizon” of the photon becomes an unfinished history, a reversible quantum being, and only after the quantum measurement is transformed into a classical being, the “present horizon” interacts with the “past horizon,” and the photon becomes an irreversible classical object. Only after the quantum measurement is transformed into classical being, and the “present horizon” interacts with the “past horizon,” the photon becomes an irreversible classical object. In other words, the “past” reality of the contemporary photon and the “present” reality will be overlaid and fused to form the “whole” reality of the photon, which is the reality of the photon, and it is precisely a “past” and “present” reality. This is the photon's reality, and it is the process of iterating the horizon (forming the whole field of view) that creates the total effect.

Of observation, the physicist Wheeler (1994) once said,

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> what is ‘observership’? It is too early to answer. Then why the word? The main point here is to have a word that is not defined and never will be defined until that day when one sees much more clearly than one does now (except in the foregoing obvious instance) how the observations of all participators, past, present, and future, join together to define what we call ‘reality.’ ” (p. 43)

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Without present observation, past realities are indeterminate, and it is only when present observation transforms past realities into determinations, they together constitute, in turn, overall reality. In quantum mechanics, the result obtained from a microscopic object to a measurement is an effect history, the result of the interaction between past and present. The photon is an unfinished “text” that exists historically, and we can understand it only from a historical perspective and a holistic perspective.

When we say that the photon is effective-historical, we do not deny that the photon itself has an intrinsic nature. Effective history does not mean the denial of the past, but means that the present and the past together construct history. What is meant by history is the overall effect of the event itself and its meaning. The photon itself has an intrinsic nature; it is the unity of entity and historical effect. A photon is the photon itself and its physical meaning as a whole.

The reason why quantum measurement of quantum mechanics becomes a difficult problem is that the process of quantum measurement is an overlay of the past horizon and the present horizon formed by the measuring instrument, which is a process of fusion of horizons and a process of effective history, which is not involved in classical measurement. In the quantum measurement process, there is a unity of explanation, explication and meaning-projection.

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