Addis Ababa University

አዲስ፡አበባ፡ዩኒቨርሲቲ

SEEK WISDOM, ELEVATE YOUR INTELLECT AND SERVE HUMANITY !

COLLEGE OF SOCIAL SCIENCES AND HUMANITIES

DEPARTMENT OF PHILOSOPHY

ON THE COMPATIBILITY OF POSSIBILISM WITH QUANTUM MECHANICS

By

Abinet Yeshiwas Kebede

October, 2023

Addis Ababa, Ethiopia

ON THE COMPATIBILITY OF POSSIBILISM WITH QUANTUM MECHANICS

By

Abinet Yeshiwas Kebede

Advisor

SETARGEW KENAW (PhD)

A THESIS SUBMITTED TO THE DEPARTMENT OF PHILOSOPHY, ADDIS ABABA UNIVERSITY (GRADUATE PROGRAM) IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS IN PHILOSOPHY

ON THE COMPATIBILITY OF POSSIBILISM WITH QUANTUM MECHANICS

By

Abinet Yeshiwas Kebede

Approved by Board examiners

____________________	____________________	____________________
Chairperson	Signature	Date
____________________	____________________	____________________
Advisor	Signature	Date
____________________	____________________	____________________
Examiner	Signature	Date
____________________	____________________	____________________
Examiner	Signature	Date

DECLARATION

I thus declare that I wrote this thesis on my own, that all of the material in it is original to me unless otherwise indicated in the text, and that I have not submitted it for consideration for any other degree or processional qualification.

Declared by Abinet Yeshiwas Kebede

Signature ___________________

Date ___________________

ACKNOWLEDGMENT

First and foremost, I would like to express my gratitude to God. He has provided me strength and encouragement during the difficult process of finishing my thesis. I am eternally thankful for His unending love, and compassion.

I would like to thank Dr. Setargew Kenaw, my adviser, from the bottom of my heart for his ongoing guidance and insightful criticism. His perceptive feedback on my studies has been really helpful in helping me achieve this goal. Had it not been for his constant encouragement and advice, I never could have finished my thesis. Additionally, I want to thank my classmates for all of their help, especially in setting up the class schedules so that they would be convenient for me. I also find it imperative to express my profound appreciation to my good friend, Samuel Ayalew, whose unwavering support and benevolence have served as catalysts for my intellectual growth and scholastic pursuits.

Finally, I would want to give my sincerest appreciation to my wonderful wife. You have been there for me through the ups and downs of my school life, and for that I am eternally grateful. Thanks for being there for me and believing in me; it really helps keep me going.

Abstract

One of the prevailing views in the field of philosophy of time is Possibilism, also known as the growing block universe theory. This theory posits that the universe is constantly growing and changing, with the past being fixed and the future being open. Nevertheless, the consistency between this theory and quantum physics remains a subject of continuous scholarly debate. This thesis gives a persuasive argument that asserts the compatibility between the theoretical framework of Possibilism and the principles of quantum physics. Through the embrace of the Copenhagen Interpretation, a profound perspective on Quantum Mechanics, wherein reality is intricately linked to the observer's presence, I posit that the very essence of the future resides within its inherent metaphysical indeterminacy. This indeterminacy, in turn, engenders a state of openness, wherein possibilities abound and outcomes remain uncertain. I possess an argument that seeks to ascertain the reality of the past, utilizing profound concepts such as the arrow of time, the enigmatic measurement problem, and the intricate phenomenon of entanglement. The inherent unpredictability of future events, which makes it imperceptible to an observer in the present, when combined with the reality the of past events, finally leads to a deep comprehension: The perspective of Possibilism, which considers the future as a realm abundant with potential rather than predetermined certainty, may be effectively integrated with the foundational principles of Quantum Mechanics.

***Key Words**:*

Possibilism, Quantum mechanics, Copenhagen Interpretation, Compatibility,

Contents

Abstracts………………………………………………………………………………… i

Contents…………………………………………………………………………..…. ii

1. **Chapter One**

   Introduction……………………………………………………………………...1

2. **Chapter Two**

   The Philosophy of Time……………….………..……………………….....................8

   2.1. *The Beginning of the Metaphysics of Time*………………………………...8

   2.2. *Substantivalism and Relationalism*…………………………………….…12

   2.3. *McTaggart and "The Unreality of Time"*………………………………….15

   2.4. *Presentism, Eternalism, and Possibilism*………………………………….20

3. **Chapter Three**

   The Physics of Time……………………………...27

   3.1. *The Concept of Time in Classical Mechanics*.………………..…………28

   3.2. *The Concept of Time in the Theories of Relativity*…………………….…33

   3.3. *The Concept of Time in Quantum Mechanics*……………………………36

   3.4. *Modern Physics and Theories of Time*……………………………………39

4. **Chapter Four**

   Compatibility of Possibilism with quantum Mechanics ……………………43

   4.1. *Observer Dependent Reality*………………………………………………45

   4.2. *Open Future* ………………………………………………………………47

   4.3. *Fixed Past in Quantum Mechanics*…………………………………….…50

      4.3.1. *Arrow of Time* ……………………………………………………….50

      4.3.2. *The Measurement Problem*…………………………………...…...51

      4.3.3. *The Role of Observers*……………………………………………..51

      4.3.4. *Conclusion*…………………………………………………………...52

5. **References**……………………………………………………………………...55

Chapter One
Introduction

Philosophy of time, which is part of the bigger field of metaphysics, is the study of time's deepest nature, existential traits, and characteristics. This study looks into various issues related to the nature of time, its connections with space and motion, and the important effects that time has on how we see the world. The philosophical study also looks at the difficult relationship between how we each see time and how theories in science describe time as an objective reality. Time seems to be a subjective entity in human experience, passing through our awareness with a fluid and ethereal aspect. When subjected to scientific analysis, however, time takes on a separate shape, losing its subjective essence and becoming a dimension devoid of the complexity inherent in human interactions.

The profound contemplation of theories concerning the enigmatic nature of time has perpetually captivated philosophers and scientists throughout the vast chronicles of humanity's ceaseless pursuit of wisdom. The diverse theories offered here provide us with a spectrum of perspectives concerning the essence of time. Among them, Presentism stands out, advocating for the notion that true existence is solely attributed to the present moment, leaving the past and future devoid of actuality. Contrarily, Eternalism postulates the notion that the fabric of time encompasses a symmetrical reality, wherein each fleeting moment holds equal significance, thereby acknowledging the past and future to possess an equivalent realness to the present. We are also confronted with the profound concept of Possibilism, which is alternatively referred to as the growing block theory. From this particular viewpoint, it is evident that the past and the present are perceived as concrete entities, whereas the future, with its intangible nature, is yet to be realized.

Quantum mechanics, a fundamental discipline within the realm of physics, encompasses the intricate study of matter and energy dynamics at minuscule dimensions. It has achieved remarkable success, having undergone rigorous testing and validation via a multitude of experiments. However, it is also a theory that challenges our reality-related intuitions. One of the fundamental principles of Quantum Mechanics is its ability to accommodate the concept of superpositions, wherein particles can occupy multiple states concurrently.

Perhaps more than any other scientific theory, Quantum Mechanics requires an explanation in order to make sense. We know that the behavior of a quantum mechanical system may be accurately described by its wave function. The development of the wave function is under the control of a wave equation. But each measurement we take only produces one real-valued result. We identify definiteness with particle nature. There is only one guaranteed measurement result left when the wavefunction is considered to have collapsed at the moment of measurement, excluding all other possibilities. The difficulty with quantum physics' failure to capture reality when no one is watching is known as the measurement problem. As a result, there are several interpretations of Quantum Mechanics for what transpires throughout the measuring process (Gao, 2019, p. 300).

Two prominent and competing interpretations of Quantum Mechanics are the Copenhagen interpretation and the Many Worlds interpretation. The Copenhagen interpretation was developed by a group of physicists including Niels Bohr, Werner Heisenberg, Max Born, and others who were affiliated with the Institute for Theoretical

Physics at the University of Copenhagen. On the other hand, the many-worlds interpretation was formulated by Everett during his doctoral studies at Princeton in 1955. It seeks to establish a connection between the domains of microscopic and macroscopic events in order to effectively tackle the problem of measurement.

The Copenhagen Interpretation posits that atomic and subatomic particles exhibit dual behavior, alternating between particle-like and wave-like characteristics. The phenomenon being referred to is often known as "wave-particle duality." When a particle is detected, it exists in its localized particle state. However, during the intervals between observed locations, a particle exists in its wave-like state. The particle's properties and behavior cannot be determined or described during the intervals between detection events. The act of detecting necessitates the process of observation. According to the first formulation of the Copenhagen Interpretation, once quantum particles come into contact with a macroscopic entity, they no longer adhere to quantum principles and instead conform to the characteristics of the macroscopic domain. The phenomenon being seen is wave function collapse. As an example, when an electron impinges onto a phosphorescent screen, it engages in an interaction with the phosphor material, resulting in the generation of a minute luminous discharge. During that particular instance, the wave function undergoes collapse. The phenomenon involves a transition from its wave-like state to its particle-like state. The spark denotes the specific location at which the electron exhibits particle-like behavior.

In accordance with the tenets of the Many-world interpretation, the cosmos is governed by a single, expansive wave function that adheres to Schrödinger's equation. In contrast to the Copenhagen Interpretation, the Many-Worlds Interpretation posits that the universal wave function does not undergo collapse.

All entities throughout the cosmos, including human beings, possess quantum properties. As human beings engage with various components of the cosmos, a state of entanglement emerges between ourselves and these components. As the universal wave function undergoes evolution, some superposition states inside our system experience the process of decoherence. When such an occurrence happens, our perception of reality becomes distinct from the other potential consequences linked to this event. It is important to note, however, that the phenomenon of the universe splitting and generating a new universe does not occur. The existence of all potential realities, or universes, is included inside the universal wave function, coexisting within the same space-time framework.

While both interpretations offer explanations for the fundamental nature of the quantum realm, I contend that the Copenhagen interpretation emerges as a beacon of enlightenment, offering a more all-encompassing and harmonious comprehension. This assertion finds support in the empirical evidence and logical reasoning that underpin its foundations, distinguishing it from its counterpart, the Many-World interpretation. The rationale for advocating for the acceptance of the Copenhagen Interpretation may be summarized as follows:

The Copenhagen interpretation is aligned with the idea of Occam's Razor, a principle which posits that the most straightforward explanation is often the most accurate. The Many-World interpretation posits the existence of several parallel worlds that proliferate exponentially after each tiny occurrence. However, this explanation is criticized for its superfluous complexity and lack of empirical substantiation. The Copenhagen interpretation, on the other hand, posits that a solitary world may adequately explain all empirical facts, thereby upholding the principle of simplicity.

To illustrate, let us contemplate a rudimentary quantum experiment whereby a particle exists in a superposition of two distinct states. As per the Copenhagen interpretation, the act of measuring results in the collapse of the wave function into a singular state. On the other hand, the Many-World interpretation postulates that the cosmos undergoes a division into two separate realities, whereby diverse iterations of the observer see differing results. The proliferation of universes in the absence of empirical evidence is a violation of Occam's Razor, since it introduces unneeded complexity.

Additionally, the Copenhagen interpretation garners significant empirical backing, hence making it a more feasible and dependable theoretical framework. Numerous years of extensive scientific testing continuously validate the concept of wave-particle duality, which is in accordance with the Copenhagen interpretation's understanding of superposition and the subsequent collapse during the act of measurement.

The renowned double-slit experiment serves as an illustrative example of the dual nature of particles, exhibiting characteristics of both waves and particles until subjected to observation, at which point it undergoes a collapse into a singular state. This adheres to the principles of the Copenhagen interpretation without providing explicit empirical support for the Many-World interpretation. The empirical outcomes of quantum experiment constantly provide evidence in favor of the concept of wave function collapse, hence confirming the Copenhagen interpretation as the most precise explanation of quantum events.

Lastly, the Many-World interpretation gives rise to several logical and conceptual issues. If it is assumed that every possible quantum consequence is realized in parallel universes, the magnitude of parallel worlds becomes overwhelmingly immense, hence raising inquiries about the mechanisms of interaction between these universes and the uniformity of physical rules throughout them. Moreover, the mechanism by which observers are confined inside a singular reality, devoid of any awareness or impact from other realms, remains ambiguous.

There is a significant pattern in the field of philosophy and science where numerous attempts have been made to examine how theories of time fit within the complex framework of Quantum Mechanics. In his article titled "Time of Philosophers, Time of Physicists, and Time of Mathematicians," Fabien Besnard investigates the potential concordance between different theories of time and the enigmatic field of Quantum Mechanics. Besnard examines various Quantum Mechanics-related assumptions and interpretations in an effort to demonstrate the potential coexistence of time and Quantum Mechanics.

The central objective of this thesis is to provide a persuasive argument in favor of the coherence between Possibilism and quantum physics, contingent upon the acceptance of the Copenhagen interpretation. The elucidation of the route towards the achievement of these goals is facilitated by the following enumeration of actions:

Chapter 2 explores a comprehensive examination, wherein a metaphysical investigation is conducted to explore the very nature of time. Upon embarking on a thorough exploration of philosophical inquiry, one shall encounter the profound viewpoints espoused by renowned philosophers in relation to this enduring topic. The subject of discussion revolves around a significant philosophical disagreement that emerged during the early modern period concerning the fundamental essence of time. It specifically explores the inquiry regarding the existence of time as distinct entities, examining whether time is independently existing or rather constructed through the attributes and interrelationships of objects. Moreover, it involves the assessment of various theories regarding its essence.

In Chapter 3, I take on a profound exploration of the concept of time as it manifests within various theories of physics. Specifically, I will discuss time according to classical mechanics, theories of relativity, and Quantum Mechanics, each offering distinctive and momentous perspectives on the nature of reality. Through this analysis, I illuminate the profound significance that each theory imparts to our understanding of existence. We shall also investigate the harmonious coexistence of temporal theories and the bedrock tenets of contemporary physics.

Chapter 4 shall attempt to construct a compelling rationale elucidating the harmonious coexistence of Possibilism and the intricate realm of Quantum Mechanics. I commence by positing the profound proposition that the fundamental essence of existence is intricately interwoven with the subjective lens of the observer. I contend that the nature of the future is one of openness, for it exists in a state of metaphysical indeterminacy. I shall further elaborate on an argument that seeks to ascertain the truthfulness of the past, utilizing profound concepts such as the arrow of time, the enigmatic measurement problem, and the intricate phenomenon of entanglement. The profound reflection upon the actuality of the past, intertwined with the intrinsic uncertainty surrounding the future, renders it intangible for an observer in the present moment. Upon deep reflection, I shall conclude that the concept of Possibilism, which views the future as a domain of possibilities rather than certainties, can be seamlessly integrated with the fundamental tenets of Quantum Mechanics.

Chapter Two
The Philosophy of Time

The pursuit of comprehending the significance and essence of time has been considered a fundamental aspect of philosophy since ancient times. The present chapter provides an overview of the historical development of the metaphysical inquiry into the nature of time. The present discourse shall commence by exploring the philosophical perspectives of Parmenides and Zeno. Subsequently, I shall provide a succinct analysis of Plato's and Aristotle's viewpoints on the concept of time. The discussion will proceed to the seventeenth and eighteenth centuries, where the focus will be on the works of Gottfried Leibniz and Isaac Newton. The discourse will center on their significant early modern philosophical dispute, which centers on the question of whether time and space are independent entities or whether they are instead formed by the attributes of objects and the connections that exist between material objects. The discourse will encompass an assessment of McTaggart's renowned 1908 argument that posits the non-existence of time. Ultimately, the focus of our discussion will be on the ontology of time as it pertains to various theories of time.

2.1. *The Beginning of the Metaphysics of Time*

Since the classical period, philosophers have been posing inquiries regarding time as mentioned above. Parmenides of Elea, a pre-Socratic philosopher, is famous for having a unique take on time that differed greatly from the traditional ideas of his day. Time, as we know it, is an illusion or a mere appearance, according to Parmenides. He contended that reality, or "being," is constant, everlasting, and indivisible (Dainton, 2016, p. 9). According to Parmenides, genuine existence is a single, unchanging entity that embraces everything. He claims that reality is timeless and unaffected by change or motion. In his opinion, time is only a subjective impression of the mortal world. In "On Nature," Parmenides' philosophical poem, he offers a contradiction between "what is" (being) and "what is not" (non-being). He defined "what is" as everlasting and unchangeable, but "what is not" is nonexistent and discarded as an apparition or illusion. Any idea of change, becoming, or motion, according to Parmenides, is illusory since it suggests a movement from one state to another, which would necessitate the partition of existence into discrete moments in time. However, he believes that genuine existence is indivisible and cannot be divided into past, present, and future. Parmenides advanced a radical philosophical worldview that challenged mainstream thought by questioning the existence of time and change (Bardon, 2013, p. 8). His ideas impacted other philosophers, like his disciple Zeno of Elea, who investigated the paradoxes of motion and time further. It's worth noting that Parmenides' philosophy provoked arguments among other ancient Greek philosophers, most notably Heraclitus, who believed in reality's perpetual flux and change. Parmenides' vision of a static, timeless existence is still a fascinating and contentious philosophical problem (Parmenides, 2020). Parmenides' perspective situates him at the forefront of a distinguished lineage of philosophers who arrived at a comparable deduction, among whom is J. M. E. McTaggart (*Ibid.*, p. 3).

Zeno of Elea, who was a disciple of Parmenides, has a unique viewpoint about the concept of time. Zeno is renowned for his paradoxes, which were formulated with the purpose of questioning conventional understandings of motion and change. One of the renowned paradoxes attributed to Zeno is the Achilles and the tortoise conundrum, whereby he describes a hypothetical situation with the quick runner Achilles engaging in a race against a comparatively sluggish tortoise. Zeno posited the contention that Achilles, regardless of his speed, would be incapable of overtaking the tortoise. He accomplished this by partitioning the race into an indeterminate quantity of incremental intervals, each necessitating a certain duration for its completion. According to Zeno's paradox, Achilles is faced with the perpetual challenge of reaching the location previously occupied by the tortoise. However, due to the tortoise's continuous movement, Achilles is unable to ever surpass its position, resulting in an infinite sequence of such instances (Bardon, 2013, p.11).

Based on this paradox, it may be deduced that Zeno held the belief that time is distinct and possibly indefinitely divided. He posited the notion that in the event that time could be subdivided into infinitesimally short intervals, any kind of motion or alteration occurring inside these intervals would be rendered unattainable. Zeno used paradoxes as a means to question the prevailing notion of uninterrupted motion and to advocate for the indivisibility of time (*Ibid,* p.12).

Zeno's paradoxes have generated substantial scholarly discourse and rigorous examination of the concepts of time and motion within the realm of philosophy, so exerting an enduring influence on the discipline of metaphysics. (Zeno’s Paradoxes, n.d.)

Plato's perspective on the concept of time is complex, as seen in his dialogues, most notably "Timaeus." His view posited time as a constructed object that has a commencement, distinct from the eternal or immutable nature of other forms or concepts. He held the belief that time functions as an essential prerequisite for the manifestation of the physical realm, functioning as an intermediary entity that bridges the eternal and temporal domains. The concept of time facilitates the emergence, transformation, and preservation of the world, as well as the establishment of structure and quantification (Bardon, 2013, p. 13).

According to Plato, the concept of time is intricately linked to the motion of celestial entities, as shown by the recurring patterns seen in the orbits of the sun, moon, planets, and stars. These heavenly entities are believed to be influenced by a higher power and are intricately linked to the systematic patterns of temporal progression (*Ibid*, p. 13)

Plato's conceptualization of time is complicatedly connected to his overarching philosophical and epistemological perspectives, including the timeless world of forms, the essence of existence, and the acquisition of knowledge. Plato posits that time functions as a constructed reality that serves to provide a connection between the material realm and the domain of eternity, so providing a structural basis for the existence and organization of the universe. (Plato's Timaeus, 2022).

Aristotle, on the other hand, had a slightly different view on time compared to Plato. Aristotle believed that time is not a separate entity or a substance, but rather a measure or numerical account of motion and change (Bardon, 2013, p.14). According to Aristotle, time exists in the world of the physical objects and events. It is not something independent of them or existing in a separate realm, as Plato believed. Time is a fundamental aspect of the natural world, intimately linked to the concepts of motion and change.

Aristotle posited that the nature of motion necessitates continuity, since it involves the movement from one place to another and is characterized by the ongoing measurement and magnitudes connected with these locations. Time is often seen as a continuous variable due to its nature as a meter that measures the progression of events in both the past and the future. Furthermore, the understanding of time is accomplished by identifying individual occurrences of the current instant within a series of events, with one preceding it and one following it. Aristotle placed significant emphasis on the concept that time serves as the dimension through which movement is measured, characterized by its sequential nature and uninterrupted flow (Aristotle, 2013; 218a–11).

Aristotle suggests the establishment of a universal unit for measuring time and provides a rationale for his proposal, highlighting three key features that seem to have major significance. The selection of a unit for measuring time is contingent upon identifying a fundamental, consistent, and uniform motion or change. He attempts to demonstrate that among the three categories of motion or change, namely, local motion, change of increase and decrease, and alteration, local motion has primacy and fundamental significance, since the other two categories rely on the existence of local motion. Moreover, Aristotle attempts to demonstrate that circular motion exhibits the highest degree of regularity and uniformity among various forms of local motion. Additionally, given that local motion is characterized by its continuity, circular motion may be considered continuous as well. Among other types of circular movements, the daily motion, which was originally interpreted as the rotation of the firmament with a period of one day, and is now understood as the rotation of the Earth, is considered the most appropriate for establishing a standard unit of time measurement for other types of motions. While revolution and time are not entirely synonymous, since some components of a revolution do not constitute a whole revolution, while segments of time are indeed time, revolution may be used as a metric for measuring time (Mittelstaedt & Weingartner, 2005, p. 106).

2.2. *Substantivalism and Relationalism*

Aristotle's claim about time seems to stimulate discussions between relationism and substantivalism, two historically competing ideas on the nature of time. The relationist theory holds that time is only a collection of links between the occurrences of those physical materials, and space is only a collection of interactions that take place between physically present objects. Nothing else can relate to time; if those things are taken away, time ceases to exist. There are no conceivable worlds where time exists but there are no things, changes, or spaces (Power, 2021, p. 11). In contrast, the philosophical stance of substantivalism posits that the concepts of space and time are ontologically distinct from physical matter and its associated events and are universally present and persistent. This perspective postulates a scenario wherein time is the sole entity in existence. It is conceivable that a universe may exist without any physical entities, such as planets, apples, streams, woods, or elementary particles. Such a universe may also lack any observable alterations. Furthermore, there is a lack of space, devoid of any other objects or spatial obstructions. In this hypothetical universe, a linear progression of discrete moments occurs consecutively (*Ibid.*, pp. 10–11).

Gottfried Leibniz, a renowned philosopher and mathematician who flourished throughout the 17th century, had a relational view of time. He held the belief that time does not possess an inherent and fixed nature, nor does it exist as a tangible thing (Bardon,2013, p. 58). Instead, time is seen as a notion that emerges through the interconnections and associations among various events and entities. Leibniz posited that the existence of time is not autonomous from things and events, but rather arises from the interconnections and engagements among them. He said that time is basically a measure that quantifies the sequence and length of these interconnections (*Ibid.*, p.117).

Leibniz refutes the notion of an absolute, external time that governs all objects and occurrences. Instead, he advances the idea that events may be deemed simultaneous from the perspective of one observer, but not from that of another. This further bolsters his relational conception of time, implying the absence of a singular, universal time experienced by all observers.

Isaac Newton is widely recognized as the most prominent substantivalist. Leibniz directed most of his arguments against Newton, who espoused Democritus' space theory. Newton’s theory postulates that time and space are fundamental concepts that precede events and processes, and are independent of matter. He posits that time is an entirely real and absolute concept, akin to a universal grandfather clock that operates autonomously. He also indicates that mathematical time, in its inherent nature, flows uniformly and independently of any external factors (Newton’s Views on Space, Time, and Motion, n.d.). In other words, just as material cannot exist without a space to do so, so can events or processes exist without a period of time during which they take place and continue to exist. But if there was no matter to fill space, and if there were no events or processes to take place in time and endure through it, space and time would still exist in the same way that both does today (Ballard, 1960, p. 50). In this paradigm, time was seen as being distinct from the universe and requiring its own measurement. It basically represented a kind of container or stage setting where physical events take place in a wholly deterministic manner and would go on even if the cosmos were completely emptied of all matter and stuff.

Newton's theory of absolute time predominated for more than two centuries despite Leibniz's repeated challenges to substantivalism, even winning the support of influential thinkers like Immanuel Kant. It is essential to note that the debate between the substantivalists and relationalists views is a crucial philosophical one with implications for a variety of viewpoints in contemporary philosophy of time.

2.3. *McTaggart and "The Unreality of Time"*

In 1908, following the dissemination of Einstein's theories of relativity, J.M.E. McTaggart, an English philosopher, composed an essay titled "The Unreality of Time," in which he advanced the argument that time does not qualify as a component of physical actuality. McTaggart differentiates between A-series and B-series configurations of entities and occurrences. The A-series ordering is employed for the purpose of classifying objects and events according to their temporal location as either past, present, or future. The temporal order of events is established by the grammatical tense employed, whereby the past tense antecedes the present tense and the future tense succeeds it. A tense is a linguistic category that denotes time and is defined by its temporal proximity and relative position to the present moment, commonly known as the 'now'. The A series demonstrates a sense of dynamism as it encompasses a sequence of events that unfold from the future to the present and then to the past.

Consider, as an illustration, the hypothetical scenario in which the statement "my child will be six years old tomorrow" were verifiable. The statement's veracity is not absolute, as it will not hold true in the immediate future, specifically within the next two days. The temporal aspect of events and objects undergoes a change as a result. In claims that involve tense, the truth values are subject to change. The B series categorizes temporal occurrences based on their temporal relationships with one another, specifically in terms of precedence, simultaneity, and succession. The B series is static since p is always earlier than q or occurs in 2014. Stated differently, if the assertion "the age of my child will be five years on March 9, 2022" is accurate, the statement will hold true consistently, including on March 10th. In other words, the temporal occurrences of events and entities remain constant. The veracity of propositions expressed in the past tense remains unchanging (Parson, 2002, p. 2).

It is evident that the A and B series are frequently employed to chronologically order events or entities, as exemplified by the statement, "The Battle of Adwa started in 1896." This sentence contains indications of both date (1896 AD) and tense (past tense, specifically "started"). This implies a strong correlation between the A and B series. The interchangeability of the A series and B series can be observed when the current date is taken into consideration, allowing for a seamless transition between the two series.

However, it is important to note that tenses exhibit variation while dates remain constant. The reduction of the A series to the B series and vice versa is not possible in the absence of a specific date. Comprehension of contemporary events, that is, the current state of affairs, is imperative despite possessing comprehensive knowledge of the historical progression of the B-series worldwide. In the given scenario, an individual may possess knowledge pertaining to chronological sequencing yet lack proficiency in grammatical conjugation. On the contrary, it is possible to possess knowledge of the spatial coordinates of all incidents in relation to the present day without possessing information regarding the current date. An individual may possess an understanding of grammatical tenses but not necessarily possess the same level of comprehension regarding chronological dates. It is crucial to underscore that the possession of knowledge pertaining to dates without a corresponding comprehension of tenses is a frequently observed phenomenon. As an illustration, an individual could possess cognizance of the designated hour of his/her appointment, specifically 10 a.m., albeit deficient in awareness of the present time owing to a malfunctioning watch.

McTaggart distinguishes between two series that arise from our perception of time and subsequently investigates whether both of these series are indispensable for our understanding of time. The B-series criterion is widely regarded as unproblematic, given that any two temporal events are intrinsically linked as either "preceding" or "succeeding." According to Richard Gale's analysis, McTaggart held the view that the self-evident nature of the necessity of the B-series obviated the need for any additional explication. McTaggart's philosophical inquiry involved the examination of the concept of time, which led him to conclude that the idea of a time that lacks differentiation between past and future is logically nonsensical (Gale, 1968, p. 10). Therefore, an investigation regarding the appropriateness of utilizing the B-series for temporal depiction arises. McTaggart presents a critical response to the aforementioned argument, asserting that the unmodifiable quality of B-determinations renders the static B-series insufficient in elucidating the notion of change. Given the inherent connection between time and change, it can be argued that the B-series is an inadequate means of accounting for time. As a result, the B-series, while indispensable for the description of reality, is inadequate in its treatment of the temporal dimension of reality, as it neglects to consider the phenomenon of change. The elucidation of a change can only be accomplished by invoking the A-series.

The presence of A-series reality is necessitated by the condition of temporal reality. The presence of an A series is a necessary condition for the existence of any B series. This is because a temporal dimension cannot exist without an A series, as per McTaggart's extensive argument (McTaggart, 1908, p. 461). Thus, it is widely acknowledged that the A-series holds greater fundamental significance in comparison to the B-series. McTaggart argues for the necessity of the A-series in explaining the concept of time. However, he also seeks to demonstrate the paradoxical and therefore deceptive nature of this series, ultimately leading to the conclusion that time does not possess authentic existence.

After arguing that the A-series is essential to explaining why time exists, McTaggart makes an effort to demonstrate how contradictory and hence illusory this series is, which leads to the conclusion that time is not really real. Every second in the A-series is either in the past, present, or future. Nevertheless, "past, present, and future determinations are irreconcilable," as every event must be either one or the other, and no event can be both (McTaggart, 1908, p. 468). However, despite the fact that these characteristics are incompatible, "every event possesses them all." P has existed in the past, the present, and the future if P is in the past. The present and past will also apply if anything is in the future. If something is current, it has been, is, or will be in the past. Therefore, each occurrence has all three characteristics. Consequently, each occurrence within the A-series exhibits three contradictory characteristics, rendering the A-series incongruous. The A-series is deemed to be contradictory and therefore lacking in reality. Consequently, time, which is contingent upon the A-series, is also considered to be unreal.

Within the realm of metaphysics pertaining to time, scholars are known to adopt either an 'A-theory of time' or a 'B-theory of time,' depending on their respective stances regarding the characteristics and connections of the sequential arrangement of occurrences. The stark contrast between these two distinct notions of time is poised to have a profound impact on our perception of reality. The A-theory, also referred to as the "tensed theory" or "dynamic view," and the B-theory, also known as the "tenseless theory," "static view," or "block universe view," are two distinct conceptual frameworks in the field (Deng, 2018, p. 1). The A theory of time posits that time has an inherent tensed or dynamic nature. The concept places significant emphasis on the subjective perception of the present moment and the continuous progression of temporal events. The theory posits that events possess temporal attributes, namely their categorization as past, present, or future. It recognizes the existence of temporal becoming, a phenomenon in which events undergo a transition from a future state to a present state and eventually to a past state. This theory of time is in accordance with our intuitive understanding of the passage of time.

On the other hand, the B theory of time challenges the notion of temporal becoming and the presence of objective moments in the present. The proposition suggests that the cosmos may be conceptualized as a four-dimensional "block universe" in which all events coexist continuously, analogous to the spatial dimensions. According to the B-theory, all occurrences possess an immutable temporal location and are arranged in a static and timeless fashion. Temporal qualities, such as past, present, and future, are often regarded as subjective illusions that rely on one's viewpoint.

The nomenclature of the B theory is derived from its assertion that temporal qualities may be most effectively elucidated via the use of B-series relations. These relations include a linear and orderly progression of occurrences, whereby the temporal positioning of events is expressed, for instance, as "event A precedes event B." The prioritization of the subjective perception of time or the flow of events is not emphasized.

B-theorists perceive time as analogous to space, where all temporal and spatial locations and their contents exist equally. B-theorists posit that in addition to the notion that a particular location is identified as "here," a specific moment in time is also identified as "present." The terms "here" and "present" are considered indexical phrases that are inherently linked to the location and time at which they are uttered.

2.4. *Presentism, Eternalism, and Possibilism*

Presentism symbolizes an extreme form of A-theory. The notion that only the current moment holds existence is held. The historical events that have occurred are now relegated to the realm of memory and no longer exist in the present. The impending temporal state has yet to manifest itself. The concept of past or future is nonexistent. The current state of affairs is characterized by dynamism, motion, alteration, and development. The phenomenon under consideration is commonly referred to as temporal becoming or the passage of time (Savitt, 2014). The concept of Presentism can be broadly defined as a perspective that encompasses two primary claims. One of the fundamental beliefs is that only the current moment holds existence, thereby limiting the existence of events and entities to the present. Assuming a temporal reference point of January 1, 2023, at midnight, then I exist sitting here typing this paper, and my wife and son also exist sleeping next door. Nonetheless, neither my deceased grandfather nor the emotional robots that will be developed in the future possess actual existence. The current state of existence is solely comprised of the present moment. The second fundamental principle of Presentism posits that distinct moments can each be regarded as the present moment. The absence of my grandfather at present leads to the conclusion that he is currently nonexistent. However, there was a period in which he was present. In the future, it is possible that we will enter an era where robots with the ability to display emotions are developed.

Consequently, a universe that is presentist is characterized by its dynamic nature, wherein it undergoes continuous changes over time. The succession of events is in a constant state of flux, with each passing moment giving rise to a fresh set of occurrences while simultaneously obliterating the previous ones.

Advocates of Presentism argue that it aligns with our common-sense understanding of time. They believe that only the present moment is accessible and directly experienced, making it the only tangible aspect of time (Bardon, 2013, p. 86). Presentists often claim that the past and future can only be understood in relation to the present. They consider Presentism to be an intuitive and straightforward way of conceiving time.

Nevertheless, Presentism encounters multiple challenges and objections. A notable argument arises from the field of physics, particularly in relation to Einstein's theory of relativity. In the context of relativity, the idea of simultaneity lacks an absolute nature, and the existence of a singular "now" poses challenges within the framework of relativity theory. The principles of relativistic physics suggest that the concept of the present moment is contingent upon an observer's frame of reference, hence allowing for the possibility of distinct present moments among various observers.

Another criticism of Presentism arises from a philosophical standpoint. Critics contend that Presentism encounters challenges when attempting to reconcile the uninterrupted nature of human identity throughout temporal intervals. The inquiry arises as to how the continuity of our unique identity can be accounted for, given the premise that only the present instant is existent.

Notwithstanding these obstacles, the idea of Presentism remains a subject of extensive discussion within the realm of philosophy. Proponents of this viewpoint persistently strive to enhance and justify their stance, whilst detractors put out alternate ideas such as Eternalism or the B-theory of time. The investigation into the nature of time continues to be a multifaceted and continuous subject of study in the realms of both philosophy and science.

Eternalism, conversely, is a time theory that presents a contrasting perspective to Presentism. The proposition suggests that every instance in the temporal continuum, including the past, present, and future, has equivalent ontological standing and persists in a state devoid of temporal progression or change. Eternalism posits that time may be conceptualized as a landscape or a block, whereby all events and things coexist in a simultaneous manner (Savitt, 2014).

Eternalists posit that objects and events that transpire at different temporal intervals are analogous to those that occur at distinct spatial locations. Similar to the existence of Athens despite its absence in Ethiopia, the existence of my grandfather persists despite his absence in the year 2023. One of the primary consequences associated with the philosophical concept of Eternalism is the rejection of the notion of temporal progression. According to Eternalism, it is deemed inaccurate to assert that the past has ceased to exist or that the future has not yet come into being. Both past and future events possess the same ontological reality as the present moment, but being subjectively experienced in distinct ways at various junctures within the temporal dimension. The temporal sequencing of events on the block is determined by their relative chronology, with the Battle of Adwa antedating the passing of my grandfather, which in turn precedes the emergence of sentient robots. The aforementioned relationships remain constant. If the temporal occurrence of the Battle of Adwa precedes the passing of my grandfather, it will remain a verifiable fact that the Battle of Adwa occurred prior to the demise of my grandfather.

Supporters of Eternalism contend that it is substantiated by the prevailing scientific understanding of time, namely within the realm of physics. The theory exhibits compatibility with Einstein's theory of relativity, whereby time is seen as a dimension coexisting with the three spatial dimensions. According to this perspective, temporal moments are distributed over this particular dimension, hence negating the existence of a privileged "now" or present moment.

A primary critique of Eternalism is to its inability to adequately include our subjective perception of time. Critics contend that the framework of Eternalism fails to fully address the dynamic and transient nature of human conscious experience, as seen by our perception of the present moment constantly shifting and evolving. The argument posits that the subjective experience of the passage of time implies an ontological distinction between the present and both the past and future. Furthermore, Eternalism asserts that all moments of time exist concurrently, denying the existence of genuine becoming and the ontological distinction between the past, present, and future. Critics contend that this perspective oversimplifies the complexity and intricacy of our experience of transformation and change. They argue that Eternalism undermines our comprehension of processes, growth, and development, which necessitate temporal progression and the potential for novelty.

Critics also express problems pertaining to the causal efficacy of events and acts within the framework of the block the universe, as posited by the philosophical concept of Eternalism. The contention put out posits that the same ontological status of all temporal moments presents challenges in elucidating the mechanisms via which one moment might exert causal effect over another. The absence of chronological sequence and immediate interaction among events is a challenge to the intuitive understanding of causation.

Furthermore, Eternalism is condemned for failing to provide a satisfactory explanation for the universe's observable apparent time asymmetry. Numerous phenomena, including the irreversibility of entropy, the directionality of causal processes, and the subjective experience of memory, readily exhibit time asymmetry. The concept of Eternalism fails to adequately explain the underlying causes of temporal asymmetry.

Possibilism, sometimes referred to as the Growing Block Universe Theory of Time, is a theory that amalgamates components of Presentism and Eternalism. It has some resemblances to Eternalism, although it presents an alternative comprehension of the ontological nature of time. We have discussed that Presentism is a philosophical viewpoint that asserts the reality of the present moment, while Eternalism affirms the presence of all times, including the past, present, and future. The perspective of Possibilism, on the other hand, acknowledges the existence of the past and present as real, while seeing the future as uncertain and including a domain of potentialities. The concept of time is often seen as a growing block, whereby new moments are continually appended to the preexisting fabric of reality.

One crucial element of Possibilism is in its recognition of subjective time. Critics of Eternalism contend that the philosophical framework falls short in encapsulating our subjective encounter with the temporal progression. In light of the above statement, Possibilism acknowledges the human perception of temporal progression, therefore accommodating the subjective encounter with the current instant as it integrates into the expanding temporal framework.

The concept of Possibilism also offers a response to the criticisms of causality and temporal asymmetry that have been made against the philosophical position of Eternalism. Possibilism maintains its causal effectiveness by including the concept of the expanding block element, which posits that new events and acts continuously emerge in every instant, hence exerting an influence on succeeding moments.

Furthermore, it is consistent with the observed temporal asymmetry, shown by the irreversibility of certain processes and the subjective perception of memories.

The realm of Possibilism encounters a serious philosophical challenge when attempting to elucidate the ontological nature of potential possibilities. Critics posit that by acknowledging the authenticity of future possibilities, we inevitably bestow a certain semblance of existence upon non-actualized futures. The contemplation of such matters invites inquiry into the essence of existence and the ontological implications of Possibilism.

The philosophies of Presentism, Eternalism, and Possibilism all address the nature of existence. There are several ways in which common English uses the word "exists." To grasp the differences between the three points of view, one must grasp the goals that underlie the claims made by each about the essence of existence. It is fair to assume that when I say "there is no internet connection," I am referring to the fact that my place of residence does not have an internet connection. Therefore, my statement may be considered true. It is untrue to say that everyone is without an internet connection—my neighbor's working Wi-Fi network is proof of this. The statement, "There is no internet connection," may only be considered untrue if we provide a contextual framework for assessing the claim. For example, if we restrict the claim to my home, it is verifiable that there isn't an internet connection.

The statement "There is no such thing as a ghost" holds equal veracity. Nevertheless, the intended implication of my statement within the confines of my house is not the absence of ghosts in that specific location, despite its veracity. Rather, it pertains to the nonexistence of ghosts in any given place. The differentiation between the two claims lies in the fact that the assertion, "there is no internet connection," can be naturally interpreted as limiting the scope of quantification to entities within my household, whereas the latter statement does not exhibit such implicit confinement. When used in a restricted context, the phrase "exists" has limited quantification. It is unlimited in its use when measuring across an unbounded range, that is, the range of all conceivable values.

The disagreement between eternalists and presentists pertains to the veracity of statements such as "there are no dinosaurs." Both presentists and eternalists concur that the aforementioned assertion holds true if we construe it as quantifying over a restricted domain, such as a particular abode or the temporal span of the year 2023. The discrepancy between their viewpoints can be elucidated solely through an interpretation of their conflicting assertions regarding the nature of existence, assuming that they are both making claims that encompass an unbounded domain.

This chapter was devoted to exploring the historical development of the metaphysical inquiry into the nature of time. We've also seen that three theories dominate the ontology of time: Presentism, Possibilism, and Eternalism. Presentism holds that only existing objects are real, Possibilism holds that the past and present are fixed and actual, and Eternalism holds that currently existing objects and times are as real as those in the past and future.

In the forthcoming chapter, I shall explore into the physics of time, contemplating and reflecting on its essence in relation to various theories of physics. Through this exploration, I aim to showcase how each theory presents a unique and significant outlook on the nature of reality.

Chapter Three
The Physics of Time

Physics places significant emphasis on time, resulting in a diverse range of explanations regarding this fundamental concept. However, it is universally acknowledged among esteemed physicists that time stands as an exceedingly challenging concept to comprehend within the framework of our universe. Throughout the ages, time has persistently baffled philosophers, maintaining its enigmatic nature despite the passage of time itself. According to Brian Greene, a contemporary theoretical physicist, mathematician, and string theorist, time is a well-known yet perplexing component of experience, as nothing can occur without taking place over a period of time.

It is acknowledged that the concept of temporal sequence allows for the discussion of change and the observation of patterns that emerge within the unfolding of world events. Furthermore, it enables the framework and structure to contemplate elements in that particular order (Greene, 2022). According to physicist and philosopher Sean Carroll, discrete occurrences within the universe can be characterized by a specific temporal designation. According to Carroll, the concept of time enables us to differentiate between various occurrences in the universe that take place at distinct intervals, which we refer to as moments (Carroll, 2023).

The definition of time seems to be a challenging task for many individuals. According to Richard A. Muller's acclaimed publication "Now: The Physics of Time," Newton, in his extensive work Principia, evaded the matter with a dismissive attitude, citing that he would not attempt to explicate on time, place, and motion, as they are already familiar to all. Although Einstein could not provide a precise definition of time, he extensively examined the idea and discovered a range of unanticipated attributes (Muller, 2016, p. 23)

Time, in physics, allows for evolution and transformation of systems and phenomena. The essence of nature is reflected in both space and time, as they serve as the platform for all its manifestations. Everything that exists is encompassed within the realm of space and time (Bertolami, 2022, p. 2). The pursuit of knowledge in physics involves the use of numerical methods to gather evidence in support of its theories, making it one of the most advanced physical sciences. The exceptional nature of physics lies in its precise measurements, rigorous empirical testing, and the elimination of theories that do not align with experimental data (Riggs, McGrath, & Jebb, 2015, p. 49).

The three fundamental theories of physics, namely classical mechanics, relativity, and quantum physics, offer distinct perspectives on time as they account for the different levels of physical reality. The objective of this chapter is to analyze and contemplate the concept of time within these theories while showcasing how each theory presents a unique and significant viewpoint on reality. An endeavor will be made to briefly investigate the compatibility of the theories of time expounded in Chapter 1 with the fundamental principles of modern physics.

3.1. *The Concept of Time in Classical Mechanics*

Newton's discovery of calculus and his understanding of gravity are credited with the development of classical physics. This paradigm views the physical cosmos as a single, enormous system that changes its configuration over time according to deterministic principles. The theory suggests that the cosmos may have been created by a god who understood mathematics and used a limited number of simple mathematical rules to start the motion of matter. These basic rules ultimately account for the complexity and variety of natural occurrences. Similarly, it may be argued that these basic principles can be used to explain any phenomenon, no matter how complex. A thorough understanding of previous events is necessary to calculate future events due to the causal structure of classical physics. Just as accurate computation of past occurrences is made easier by the availability of detailed future data.

As expounded in Chapter 1, the concept of time in classical physics is commonly denoted as absolute time, which is also known as Newtonian time. The notion of absolute time posits that time is independent of the observer or entity that experiences it (Greene, 2004, p. 46). It moves at a consistent velocity across the cosmos without any interruptions. It is believed to possess properties that are not easily discernible by numerical means. This is the prevalent perception and experiential understanding of time among individuals. According to Claudio Borghi, time is a mathematical parameter utilized in Newtonian mechanics to depict the alteration of physical quantities without necessarily signifying a tangible real-world correlation. In Newton's world, the concepts of past, present, and future are universally applicable to all entities as they engage in various forms of motion, orbital behavior, attraction, and internal transformations. The concept of duration pertains to an intangible characteristic of a complete entity, while the co-occurrence and length of events are considered objective realities. The temporal progression that clocks represent is solely achieved through their physical movement, as the spatial dimension is where objects undergo motion and development. This progression is characterized by discrete moments and intervals that are not inherent to the objects themselves (Borghi, 2018, pp. 100–101).

As temporal qualities, the notions of durability and locality show a strong relationship. Time is described as local in classical physics, which is consistent with human perception. The term "locality" usually refers to spatial dimensions. Main argument of it is that to get from point O to point P, you have to go a particular distance. Given that the maximum possible speed is limited, locality requires a non-zero amount of time to travel a given distance. Interestingly, Newton's theory posits that gravity extends instantaneously, thereby indicating that his universe is not entirely local, which is a fascinating departure from commonly held beliefs (Karpenko, 2016, p. 8).

As I have just described, all material bodies move with regard to space and time according to Newton's theory. It is possible to think of space and time as an invisible, immutable, four-dimensional framework with uniform measurements that covers the whole cosmos and enables the movement of material objects. Moreover, it is evident that time and space are independent of one another, meaning that the temporal and spatial intervals between occurrences have no bearing on the spatial intervals between them. Most people agree that these two ideas are eternal and that they represent a universal truth about the universe (Curtis & Robson, 2016, p. 198).

Besides, time experiences itself at the same rate for everyone, regardless of where they are in space or how fast they are moving. Two accurate clocks that are synchronized at one point in time will always show agreement in the amount of time that has elapsed when they are brought together and compared at any other point in time, regardless of the distance that they have travelled in the interim. Any two occurrences' spatiotemporal interval is an invariant quantity that doesn't change depending on who is observing. Two events may occur concurrently and this is another intrinsic property; the temporal separation of the occurrences does not change the geographic distance between them. The events that make up the cosmos may be divided into groups, each of which occurs independently of all other groups and in parallel with all other events in that group. The collections indicated above are sometimes referred to as simultaneity hyperplanes (*Ibid.*, p. 198).

The field of classical thermodynamics employs the fundamental principles of entropy and the second law of thermodynamics in order to provide a comprehensive understanding of the fundamental nature of time. Entropy is a basic physical parameter that measures the inclination of a system to adopt its most likely configuration. The second law of thermodynamics theorizes that the entropy of a closed system will always increase as time progresses. This law, also known as the "arrow of time," posits that the irreversibility of the physical world is an inherent and basic attribute (Welch, 2006, p. 2). This observation might be seen as indicative of the development of temporal progression, wherein the concept of time can be understood as a movement from less probable states to more probable ones, ultimately leading to a state of equilibrium that is considered the most likely outcome. The crux of the matter comes in recognizing that regardless of the road or means by which we navigate, we are inevitably subject to seeing time's inexorable advancement along a unique trajectory, unceasingly moving us from the realms of the past towards the unexplored areas of the future (Karpenko, 2016, p. 9).

According to Max Planck, if irreversible processes were not present, the fundamental underpinnings of the second law would collapse, necessitating a theoretical reassessment. He had the belief that the expansion of entropy served as a comprehensive metric for assessing irreversibility on a global scale. In this regard, thermodynamics seems to exhibit a notable disparity when compared to other branches of classical physics, particularly mechanics, which demonstrates symmetry under time reversal. The reconciliation of the thermodynamical arrow of time with a mechanical worldview is widely seen as the most formidable issue in the theoretical underpinnings of thermal and statistical physics (Uffink, 2001, p. 3).

Arthur Eddington, a well-known astrophysicist, coined the phrase "arrow of time" in the year 1927 (*Ibid.*, p. 13). With the exception of a limited number of very uncommon and infinitesimal occurrences, the laws governing the behavior of physical phenomena do not demonstrate any intrinsic inclination towards a certain directionality of processes at the basic and microscopic scale. A multitude of unidirectional phenomena manifest throughout the cosmos, whereby entities endure the process of chronological progression rather than undergoing rejuvenation. According to Brain Greene, the differentiation between the advancement of time in the forward and backward directions is a significant feature of sensory reality. If temporal symmetry were equivalent to spatial symmetry, the observable characteristics of the world would be significantly altered. Greene posits that in the event if eggs exhibited an equal frequency of breaking and un-breaking, candles had an equal frequency of melting and unmelting, and human memory possessed an equivalent capacity for retaining knowledge about the future as it does for the past, substantial ramifications would ensue. (Greene, 2004, p. 13).

According to the assertions of Professor Sean Carroll, the demarcation between the past, present, and future is not an inherent property of time but rather a consequence of the arrow of time, which is contingent upon the arrangements of macroscopic matter in the cosmos. The indication of temporal progression and the traversal of distinct events is posited through the manifestation of the arrow of time. When viewed from that perspective, it is evident that the past does not possess a greater degree of reality than the future. Rather, it is more real due to our enhanced understanding of it. Accessibility is comparatively higher in the present as opposed to the future (Carroll, 2012, p. 13).

The concept of time's arrow is currently a topic of debate among physicists who are attempting to understand its origin and nature. There are differing opinions on what exactly constitutes an example of time's arrow as well as how best to describe and define this phenomenon. There are physicists who hold the view that the directionality of time, commonly referred to as time's arrow, is an inherent property of time itself, intimately linked to its progression and unbroken continuity. Conversely, there are those who posit that time's arrow is an extrinsic phenomenon arising from the various processes occurring in the natural world. This latter group argues that the directionality of time is a statistical matter arising from the presence of disorder and a specific configuration of the universe during the early stages of the big bang (Lui, 1993, p. 620).

As per the analysis of Professor Carroll, a universe that lacks an arrow of time can result in only two probable consequences: either a state of temporal stasis where no alterations take place over time, or a state of stochasticity, where events manifest haphazardly and exhibit variability in their occurrence. The human condition requires the presence of temporal directionality due to our inability to conceive of a reality in which the past and future are governed by symmetrical principles (Carroll, 2012, p. 27).

3.2. *The Concept of Time in the Theories of Relativity*

The profound theories of Special and General Relativity, developed by the brilliant mind of Albert Einstein, stand as pillars of scientific knowledge, fortified by the weight of empirical evidence. These theories, surpassing all others in the annals of science, have bestowed upon us profound insights into the enigmatic nature of time. Theories of relativity assign a specific position to time as an inherent coordinate. The invariance of the speed of light in a vacuum across all observers, irrespective of their motion, implies a fundamental interdependence between time and space. Furthermore, in adherence to the principle of causality, the theory of relativity stipulates that the ultimate velocity for the transmission of energy or information is the speed of light in a vacuum (Hawking, 1998, pp. 26–27). Riggs posits that logical inconsistencies may arise in cases where the restriction on cause and effect in the observable macroscopic world is not upheld, leading to a reversal of the relationship between cause and effect. (Riggs, 2015, p. 51).

The special theory of relativity positions all occurrences in the history of the universe within a four-dimensional manifold of points known as Minkowski spacetime. The Minkowski spacetime obtains a distinct geometrical structure through the utilization of a distance function that operates between adjoining spacetime locations. The well-definedness of this distance function remains unaffected by the presence or absence of physical events, matter, or fields. According to Dieks, there is a discernible spatiotemporal configuration present within a completely vacant Minkowski spacetime (Dieks, 2012, p. 105).

The determination of the time duration between two distinct events remains uncertain due to the absence of a time function in Minkowski spacetime. Twins can serve as a suitable illustration of this phenomenon, wherein one twin stays on Earth while the other embarks on a space voyage and subsequently returns. The phenomenon of a space traveler returning younger than their twin sibling can be attributed to the difference in the amount of time that has elapsed along the Earth's world line and the space traveler's world line. The reason for this phenomenon is that the maximum length of straight lines in Minkowski spacetime exceeds the duration experienced by the traveler along their world line (Ibid., p. 106).

As per the Special Theory of Relativity, the absence of absolute simultaneity exists between events transpiring at distinct spatial points or among objects in motion at different velocities. This statement suggests that the concept of a universal present moment is nonexistent and that the present moment is subjective and dependent on individual observers. Differences in time for multiple observers become noticeable only when the relative speed between them exceeds half the speed of light in a vacuum. Nevertheless, these discrepancies can be quantified even at significantly reduced speeds. The phenomenon commonly referred to as 'time dilation' is characterized by a hypothetical scenario involving two observers, wherein one of them undertakes a roundtrip journey through space at a velocity that approximates the speed of light. In addition, empirical evidence has demonstrated the phenomenon of time dilation with remarkable accuracy through experiments involving elementary particles and mobile atomic timepieces (*Ibid.*, p. 52; Hawking, 1998, p. 38).

The General Theory of Relativity is a scholarly endeavor aimed at comprehending the impact of gravity on the structure of space-time. Establishing a connection between gravity and the four-dimensional geometry of space-time allows for the expansion of fundamental geometrical concepts. The statement also illustrates the influence of gravity on time, as the temporal gaps between events are contingent on the relative speed, the existence of a gravitational force, and its intensity. The time dilation phenomenon can be interpreted gravitationally, as evidenced by rigorous experimentation (Riggs, 2015, p. 52; Bertolami, 2022, p. 7). As an object approaches the source of a gravitational field, the temporal intervals measured by a clock in its vicinity become progressively shorter. Riggs asserts that the temporal disparities among different Earth observers, although imperceptible, must be acknowledged as genuine and applicable (Riggs, 2015, p. 52).

Stefan Hawking posits that space and time are dynamic variables in the context of general relativity and that all occurrences in the cosmos are subject to the influence of these variables. The motion of a physical entity or the application of a force induces a modification in the curvature of space and time. The configuration of space-time is responsible for the dynamics of physical entities and the effects of forces. According to

Hawking, discussing space and time beyond the confines of the universe is illogical, much like discussing events within the universe without the incorporation of space and time is irrational (Hawking, 1998, p. 39). It is noteworthy to mention that within the framework of classical physics, space and time were perceived as an immutable backdrop against which events unfolded. It was believed that they remained unaffected by the occurrences that transpired in that location.

In short, the concept of absolute simultaneity has been deemed impossible, as evidenced by the findings of special relativity. This theory has revealed a previously inconceivable level of diversity in the methods utilized by different observers to measure the progression of time. In addition, Carlo Rovelli avows that the theory of general relativity does not deem any of the measurable parameters to be autonomous while elucidating their interdependent alterations. According to Rovelli, there exists a potentially infinite set of variables, any of which could function as the temporal variable without requiring recognition of the objective existence of a physical quantity related to time. The dynamic nature of spacetime, influenced by the presence of matter and energy, results in curvature that impacts the local clock rates. Both theories are governed by local classical variables, despite the fact that time is not perceived as passing uniformly by all observers (Rovelli, 2011, p. 3).

3.3. *The Concept of Time in Quantum Mechanics*

There are numerous interpretations of Quantum Mechanics, but only four are generally acknowledged. The Copenhagen interpretation and the many-worlds interpretation are derived from standard Quantum Mechanics. It may be more accurate to refer to the third and fourth theories as proposals for replacing Quantum Mechanics with a closely related theory, since they both begin by modifying Quantum Mechanics theory. These modifications are known as theories of hidden variables and spontaneous collapse.

Leaving aside these interpretations, the formalism of quantum theory simply replicates what is conveyed by the other theories, whether they be Newtonian or relativistic, and doesn't suggest anything particularly unique about time (Butterfield, 2012, p. 3). We are aware, for instance, that Schrödinger's equation, which enables the computation of the system's earlier and later states, is how Quantum Mechanics characterizes a physical system. According to Newtonian physics, the Schrodinger equation in non-relativistic theory implies a fixed notion of time that is absolute time (Zeh, 2009, p. 787). These quantum theories use time mainly as a coordinate and as a parameter in the equations of motion, with appropriate qualifiers for field theories and the relativistic blending of space and time coordinates. Even if time is a physical quantity, there are complications and even disagreements around it since, in accordance with quantum theory, all physical quantities are represented by operators, and defining a time operator involves complications (Butterfield, 2012, p. 9).

There are three main ways that time is utilized in quantum physics, according to Edward Anderson, who references Paul Busch in *The Problem of Time: Quantum Mechanics Versus General Relativity.* The first is called **external time**, commonly known as laboratory time in this context. It is the setting that classical physics left behind for the Newtonian era. This gives a numerical record of the setup, duration, activation, and deactivation of external fields, among other aspects, of the experiment. It is not dynamically related to the quantum entities being studied in the experiment at issue since it is being monitored by a different external laboratory clock. Examples that fit the bill include measurement time, measurement length, and the period between a measurement and preparation. Second, we have a time measurement dynamical variable for the system under investigation called **Dynamical time**. For instance, one would be able to read the time if they could track the motion of a classical free particle and read its position in reference to the background space. These concepts of time include the lifespan of unstable quantum states, the quantum tunnelling dwell time, and the scattering experiment time delay. The third kind of time is called **Observable time**, and it has extra operational consequences because of the participation of both the measuring equipment and the quantum item that is being investigated. In this particular scenario, the measured time is known to have physical importance as a time, therefore observable time has additional operational implications. A good illustration of this would be the notion of the time at which one's detector receives a signal from a source (Butterfield, 2012, pp.17-18; Anderson, 2017, p. 60).

The Schrödinger equation provides a fundamentally different concept of time than general relativity by showing how the arrangement of electrons affects the geometrical shapes of atoms and molecules. Bryce DeWitt modified Schrödinger's equation in 1976 in order to show many possibilities for the composition of the universe and the placement of everything inside it. Atoms may interact with one another and change their energies, but the cosmos only has one constant total energy and no other entities with which to interact. The primary difference between Schrödinger's quantum version and DeWitt's cosmic version of the equation is this: The Wheeler-DeWitt equation can best be solved by taking time out of the equation since the universe's energy does not change with time (Ma, 2003, p. 3).

The Problem of Time arises from the conflict between the conceptions of "time" in general relativity and quantum physics. When both of their conditions are satisfied, it is challenging to integrate these two branches of physics into a single framework. And this is supposed to be the main impetus for developing a quantum gravity theory.

Recent years have seen the development of alternative theories of time in Quantum Mechanics, notably in the context of quantum gravity. According to one of Carlo Rovelli's arguments, researchers need to "forget time" in order to develop a good quantum theory of gravity. He asserts that we must fully give up the idea of time and create a quantum theory of gravity in which it does not exist at all in order to provide a fundamental explanation of nature (Rovelli, 2011, p. 1). Even though time must disappear when moving to a higher level of description, it may then be altered in certain situations. Rovelli urges us to think of mechanics as describing the relative development of variables rather than the evolution of a system in absolute time by highlighting the serious problem with General Relativity's lack of a selected independent time notion. Time is thus seen as a feature of macroscopic systems that emerges and has no effect on quantum physics. (Qureshi-Hurst and Pearson 2020, p. 666).

Lee Smolin, another theoretical physicist who focuses on the problem of quantum gravity, discards the idea that time needs to be eliminated as a fundamental concept and proposes that the problem can be resolved by reformulating the basic mathematical framework that both classical and quantum physics are based on. By including observers in sophisticated quantum theories of the world, time is shown to be essential. He discusses quantum cosmology in terms of histories, which require several observers to make a number of simultaneous observations. Smolin asserts that time is the most basic feature of reality and that time itself creates and develops all other aspects of reality, including the rules of physics (Ibid., p. 667).

3.4. *Modern Physics and Theories of Time*

Chapter 1 covered the three metaphysical perspectives on time: Presentism, Eternalism, and Possibilism. Both eternalists and presentists agree that people who are alive right now exist, such as myself while I'm writing this paper, my child, who keeps distracting me with a barrage of puzzlingly straightforward questions, and everyone else who is now residing on the planet. Eternalists also believe in the existence of Aristotle, Newton, the first child born after 100 years, and maybe even aliens living with humans on Earth. Presentists, however, contest that none of these things are really true. The notion posits that there is no existence beyond the immediate current instant. The concept of the past is characterized by its lack of existence in the present moment. The forthcoming period is anticipated, but, it has not yet materialized. The concept of past or future lacks existence. Contrarily, Possibilists agree with Eternalists that Aristotle and Newton existed, and they concur with Presentists that the First Person Born After a Century did not occur and that extra-terrestrial life is not coexisting with humans on Earth (Figg, 2017, p. 1).

The perspective of Presentism is characterized by its adherence to the A-theory of time. A-theoretic perspectives posit that temporal events possess attributes of pastness, futurity, or presentness. The traits possessed by events undergo changes over time. The passage of time results in the progression of future events to the present, followed by their transformation into past events. "Tensed theories of time" is an alternative term used to refer to these theories. According to Dempsey, one of the fundamental principles of A-theoretic viewpoints is the conviction that the passage of time is an unalterable characteristic of the cosmos (Dempsey, 2013, p. 4).

Eternalism, on the other hand, asserts that every event, whether it occurred in the past, present, or future, already exists. The block-universe idea is another name for Eternalism. According to the B-theory, Eternalism is the most widely accepted interpretation of temporal ontology. We may conceive of time as being similar to space using this method. From this perspective, neither this place nor this time in history is seen to have a superior grasp of reality or ontological superiority over the other. It's also crucial to note that eternalists do not deny that people have encountered the passage of time, but they contend that time is not a fundamental characteristic of the universe. According to Eternalism, the passage of time is not an objective feature of the universe but rather results from the B-theoretic characteristics of events and how people perceive the world (*Ibid*., p. 5).

The growing universe theory, an intermediate theory of Possibilism, holds that everything that has ever been in the past or is presently existing exists, but nothing that will completely exist in the future does. Possibility theory seems to capture our conception of time and existence to a great extent. Even though Presentism's minimum symmetry is appealing, it misses a number of important asymmetries that pertain to the past and future. And it seems that one's actions in the present may actually realize certain present possibilities but not others, but it appears that earlier actions no longer allow for earlier choices. It is widely acknowledged that a present cause cannot touch or influence the past, even if one accepts the idea that an effect may happen before its cause in time. It would only serve to affirm the truth of the past (Savitt, 2021).

It has long been debated whether these theories of time are compatible with the three fundamental principles of modern physics: the special theory of relativity, the general theory of relativity, and Quantum Mechanics.

Numerous scientists, including Einstein, have argued that Presentism is incompatible with the special and general theories of relativity due to the relativity of simultaneity. We have shown that the four-dimensional Minkowski spacetime of relativity, which identifies every event at its date and location together with its spatial and temporal liaisons, is a perfect representation of the history of the world, enlarged both in time and space. According to the Special Relativity Hypothesis, inertial objects experience time differently because they move through space at varied speeds with respect to one another. There are thus several "nows," each of which an observer or object experiences differently depending on their velocity with respect to other observers or things. These effects intensify when the observers' relative velocities approach the speed of light (Hughes, 2019, p. 1).

The relativity of simultaneity, which seemed to imply an eternalist conception of time instead, confounded our presentist intuitions. According to this theory, past, present, and future events live in an essentially four-dimensional reality, or block universe, on an equal footing. As a consequence, eternalist interpretations of time are currently preferred among time philosophers (Savitt, 2014). It is important to remember that this argument has, throughout the years, been refuted by a lot of specialists.

Despite the fact that the issue of the nature of time in Quantum Mechanics has not received as much attention, particularly when compared to the enormous amount of work that has been done on interpretive matters, there have been attempts made by a variety of academics to address the compatibility of time theories with Quantum Mechanics. In the next chapter, I will provide my case for the contention that Possibilism is consistent with Quantum Physics when certain conditions are met. Fabien Besnard's thesis, which was provided in his paper titled Time of Philosophers, Time of Physicists, and Time of Mathematicians, will serve as the primary foundation for my line of reasoning throughout the chapter.

Chapter Four
Compatibility of Possibilism with Quantum Mechanics

The essence of Quantum Mechanics lies in its profound ability to elucidate the fundamental nature of matter and energy, particularly when examining the complex realms of atoms and subatomic particles. Quantum mechanics, a profoundly triumphant theory, has traversed the realms of scientific inquiry, subjecting itself to rigorous experimentation and meticulous validation. However, this theory presents a profound challenge to our innate comprehension of the intrinsic essence of existence. The profound quandaries posed by the notions of wave-particle duality and entanglement within the realm of Quantum Mechanics have undeniably confronted the foundations of classical physics. The aforementioned concepts contemplate the potentiality of particles existing in a state of superposition, transcending the boundaries of conventional spatial separation, and becoming entwined with one another.

The deep contemplation of the essence of time forces people to face the complex puzzles given by the mysterious field of quantum physics, in which the random actions of particles have ultimate authority. One comes across the important idea of irreversible changes that help to separate the past from the future in the field of quantum physics. The deep phenomena of measurement force a particle to adopt a single quantum state, letting go of its previous existence in a multitude of states, all coexisting harmoniously. The inherent randomness and unpredictability of individual observations contribute to their mysterious nature, but the aggregate behavior of particles adheres to statistical patterns. The perplexing discrepancy between the indispensable essence of time as seen in the domain of quantum physics and its operation within the context of relativity has given rise to a condition of ambiguity and bewilderment.

Furthermore, it is crucial to recognize that Quantum Mechanics, as a theoretical framework, contains several interpretations, each offering a nuanced portrayal of the inherent essence of time. The investigation into the complex relationship between Quantum Mechanics and conceptions of time has engrossed the intellectual pursuits of both philosophers and scientists who passionately support these viewpoints, including the extensive domains of physics and philosophy. The substantial investigations conducted by philosophers of science have been deeply entwined with serious dialogues about the profound ramifications of quantum physics on the fundamental notions of Presentism, Possibilism, and Eternalism. Quantum mechanics has been actively involved in the continuous effort to comprehend the fundamental nature and significant implications of time. However, the cryptic nature of time remains a perplexing phenomenon, defying definitive comprehension and compelling us to embark on an everlasting pursuit for elucidation.

Within this current chapter, I shall present an argument that delves into the profound compatibility between the philosophical concept of Possibilism and the intricate domain of Quantum Mechanics. The chapter further contains the overall conclusion of the thesis, accompanied by an argument for the incompatibility between the Many-world interpretation of Quantum Mechanics and Possibilism.

This Copenhagen Interpretation of Quantum Mechanics may be explored in great detail while thinking about the nature of existence. A strong argument that the scope of reality is closely entwined with the viewpoint of the observer arises under this paradigm. I contend that the essence of the future lies in its intrinsic metaphysical indeterminacy, thus leading to its state of openness. I shall also expound upon an argument that endeavors to establish the veracity of the past, employing profound notions such as the arrow of time, the enigmatic measurement problem, and the intricate phenomenon of entanglement. When the past and the future are compared, one can come to a profound understanding: Possibilism, which views the future as a realm filled with possibilities rather than a definitive existence, can coexist peacefully with the principles of Quantum Mechanics. This is because the future is inherently uncertain, making it nonexistent to a present-day observer.

4.1. Observer Dependent Reality

According to the Copenhagen Interpretation, the ontological status of reality is dependent on the involvement of an observer, suggesting that the act of observation has influence on the properties and behaviors of particles. This approach challenges the notion of a fixed and impartial reality, proposing instead that the nature of reality is influenced by human perspectives.

The classic double-slit experiment serves as a demonstration of the idea of wave-particle duality, a fundamental premise within the framework of the Copenhagen Interpretation. When a coherent beam of light or a stream of electrons is directed towards a screen with two narrow slits, it produces an observable interference pattern, so providing evidence for the wave-like characteristics of the beam. However, the aforementioned phenomena fail to exhibit itself when a person is present to determine the precise aperture through which the particle passes. The wave function undergoes a collapse into distinct particles upon observation, since the act of observation itself triggers this transition.

The experiment with Schrödinger's cat serves as an additional instructive example that emphasizes the influence of the observer on the nature of reality, particularly in the context of quantum superposition and entanglement events. According to the framework of this hypothetical situation, a cat that is enclosed inside a container experiences a condition of coexisting life and death until it is exposed to the act of observation. According to the principles of the Copenhagen Interpretation, when the box is opened, the superposition collapses, leading to the determination of a single state for the cat. Hence, the perception of reality is dependent upon the actions carried out by the observer.

Furthermore, the phenomena of quantum entanglement offer substantiation for the notion that the nature of reality is contingent upon the presence of an observer. When two particles experience the phenomenon of entanglement, their respective attributes demonstrate immediate correlation, regardless of the geographical separation between them. However, the status of entanglement remains uncertain until a measurement is conducted. In a certain moment, the act of observation performed by an observer leads to the collapse of the wave function, hence causing the properties of each particle to acquire well-defined values.

According to Rochelle Forrester, the notion that quantum entities are primarily influenced by the act of observation aligns with the concept that the fundamental nature of existence is influenced by the intricate interplay of the observer, the observed entity, and the observational environment. The relationship between macroscopic phenomena, such as cats, and the act of observation is deeply interconnected within the broader scope of this subject matter. The limitation of our comprehension and recognition of reality stems from our confinement to the domain of visible occurrences, namely the impressions we get from our sensory experiences. In the absence of an observer, events cease to exist, resulting in a condition of noticeable absence (Forrester, 2017, pp. 38–39).

4.2. Open Future

The notion of an inherent disparity between the past and the future is a deeply rooted and enigmatic sense that permeates our comprehension of temporal dynamics. The perception of the past often entails a static nature, without the capacity for transformation, and characterized by its unalterable state, rendering it inaccessible for modification.

The concept of Possibilism, also referred to as the growing block theory, presents a deep viewpoint asserting that the future, with all its mysterious allure, lacks tangible reality. Therefore, it adopts a condition of uncertainty, encouraging reflection and investigation of its limitless possibilities. The intrinsic openness of this phenomena is adequately recognized. The notion of "openness" refers to the existence of several potentialities, without a definitive resolution about the eventual actualization of any specific choice.

I agree with the perspective put forward by Cristian Mariani and Giuliano Torrengo on the idea of the openness of the future as a manifestation of objective indeterminacy. Given the intrinsic unpredictability of future outcomes and the evolution of many qualitative phenomena in the cosmic domain throughout time, one might deduce that the forecasting of contingent future occurrences is inevitably characterized by uncertainty (Mariani & Torrengo, 2021, p. 4).

The foundation of my thesis about the philosophical uncertainty of the future within the context of quantum physics is rooted in the intrinsic probabilistic nature of measurements and the consequent collapse of the wave function. According to the generally accepted Copenhagen interpretation of quantum physics, the wave function is used as a mathematical representation to express the probabilities linked to different outcomes that may occur during the process of measurement. However, a conclusive outcome is not determined until the measurement is conducted.

The Heisenberg uncertainty principle, a key tenet in the realm of quantum physics, postulates the presence of an intrinsic constraint on the simultaneous determination of a particle's exact location and momentum. The aforementioned principle posits that as one endeavors to enhance the precision of measuring a particle's position, the corresponding understanding of its momentum becomes progressively uncertain. Conversely, when aiming to measure the momentum of a particle with greater accuracy, the presence of this inherent uncertainty presents a challenge to the deterministic nature of classical physics. This suggests that certain attributes of particles are fundamentally indeterminable.

Moreover, the presence of quantum superposition reinforces the argument of metaphysical indeterminacy. The concept of superposition asserts that a particle has the capability to exist in several states simultaneously until an act of observation or measurement is executed. This implies that before the process of measurement, the state of the particle is characterized by uncertainty and exists in a superposition of all possible states. Therefore, the final outcome of a measurement cannot be accurately predicted owing to its dependence on the probabilistic collapse of the wave function.

Moreover, empirical evidence has been provided by experiments such as the double-slit experiment and Bell's theorem experiments, lending credence to the concept of indeterminacy in the field of Quantum Mechanics. The tests that were done have yielded concrete proof supporting the notion that particles may exhibit wave-like properties and exhibit non-local correlations. These findings provide a significant challenge to established notions of determinism and locality.

The examination of the metaphysical uncertainty that is inherent in quantum physics prompts a deep investigation of the fundamental nature of reality, causation, and the concept of free will. The consideration of the inherent uncertainty surrounding future events, prior to their observation, is a significant obstacle to the conventional understanding of a cosmos ruled by deterministic rules. The notion posits that the nature of reality has an intrinsic characteristic of openness, suggesting that the progression of phenomena is not predestined but rather susceptible to the impact of observation.

Moreover, the existence of indeterminacy in the domain of quantum physics leads to significant consequences for the fundamental nature of free will. If the inherent unpredictability of the future is really there, it creates the possibility for genuine randomness to emerge inside the domain of decision-making. This concept prompts a profound inquiry into the nature and mechanics of determinism. Moreover, it demonstrates the inherent capacity of individuals to exercise their autonomy within a realm characterized by quantum indeterminacy.

The examination of epistemological and ontological factors might enhance the argument for the metaphysical indeterminacy of the future. Within the field of epistemology, it is essential to acknowledge the fundamental constraints that are pervasive in human cognition. The human capacity to see and understand the universe is inherently limited by the finite constraints of our sensory abilities and cognitive faculties. The intrinsic constraints of human understanding and capacity to make predictions suggest that, even within a deterministic framework, a subjective degree of uncertainty will persist.

Furthermore, the ontological existence of genuine chance and randomness in the structure of the cosmos presents a significant obstacle to deterministic frameworks. As discussed earlier, one of the best examples of the intrinsic ontological indeterminacy is the idea of quantum events. If one takes into account the potential of true randomness within the complex fabric of reality, the significant conclusion is that the future is not defined just by the past. Instead, it reveals a world that is open-ended and in which the course of events depends on the complex interactions of probabilistic outcomes.

4.3 Fixed Past in Quantum Mechanics

The mysterious attraction of quantum physics is its reflection on the existential character of the past as we understand it and its possible presence in the complex structure of the quantum world. By means of a thorough analysis of key concepts including the measurement problem, the arrow of time, and the complex role of observers, I will attempt to provide a strong case for the reality of the past.

4.3.1. The Arrow of Time

Regarding the basic imbalance between the past and the future, the arrow of time implies that things happen in a certain, irreversible order. The advent of quantum physics has left us feeling profoundly unsettled and sparked heated discussions about the underlying causes of past events. Recognizing the fascinating idea of retro causality—which permits the effect of future events on the past—is crucial when comprehending the intricacies of quantum theory. All the same, it is crucial to recognize that retro causality does not negate the verifiable past events. History is the delicate thread that weaves together the complex fabric of reality since it is in history that cause and effect first emerge. Just like a strong, steady foundation, the foundation of past experiences and events serves as the basis for the construction of future events.

Consequently, historical knowledge is crucial to clarifying the complex causal link in quantum physics.

4.3.2. The Measurement Problem

The measurement issue in Quantum Mechanics arises due to the peculiar behavior shown by particles existing in the quantum domain. The thesis asserts that prior to being seen, the existence of a particle is manifested as a superposition of several states. Within the domain of quantum physics, an intriguing occurrence occurs upon the taking place of a measurement event. At this particular stage, the characteristics of a particle, while in a state of superposition, experience a significant change, resulting in the convergence into a single and unambiguous state (Gao,2019, p. 300). This inquiry provokes contemplation regarding the ontological nature of the past: Does the past possess an unequivocal state of being, or does it too reside in a state of superposition until subjected to observation?

I believe that a period of time that was marked by a clear state must have existed before the measurement process in question to make sense. To observe something, you have to believe that the complex web of events that happened in the past has put the current state of the system you are looking at together. When we think about the measurement problem, we come to a deep realization: it doesn't make the past less real; instead, it's a powerful reminder of how observation is key to the collapse of quantum superposition and the discovery of a clear and real state of existence.

4.3.3. The Role of Observers

The profound essence of Quantum Mechanics lies in its unwavering emphasis on the pivotal role played by observers within the measurement process. The profound notion posits that the very act of observation, in its essence, possesses the power to bring about the collapse of the enigmatic wave function, thereby unveiling the definitive outcome of a meticulously designed experiment. The implication arises from the recognition that the authenticity of the past is intertwined with the influence it exerts upon the observations made in the present. The profound comprehension of the present state of a system is intricately intertwined with the observer's acquisition of knowledge regarding past events.

Moreover, the notion of entanglement bestows gravitas upon the contention regarding the reality of the past. In the realm of Quantum Mechanics, the phenomenon of entanglement unveils a profound interconnectedness between two particles. As these particles intertwine their destinies, their inherent properties become inextricably linked, transcending the confines of spatial separation. The profound correlation observed implies the existence of past events, which have intricately woven together and exerted their influence upon the current state of the entangled particles. The presence of entanglement, in all its enigmatic glory, lends credence to the profound concept of a tangible past within the quantum realm.

4.4. Conclusion

This thesis contains a strong argument stating that Possibilism and the complex field of quantum physics are compatible. By adopting the Copenhagen Interpretation of quantum physics, I began a discourse in which I proposed that the existence of an Observer is a necessary condition for the nature of reality. This leads me to my hypothesis, which holds that the realm of Quantum Mechanics unveils an open future, thereby rendering it metaphysically indeterminate. The contemplation of the metaphysical indeterminacy inherent in the realm of Quantum Mechanics arises from the profound recognition of the probabilistic nature of measurements and the subsequent collapse of the enigmatic wave function. I have then engaged in profound contemplation regarding the veracity of the past. Through the utilization of pivotal notions such as the arrow of time, the enigmatic measurement problem, the intricate interplay of observers, and the enigmatic phenomenon of entanglement, I have embarked upon a philosophical discourse to ascertain the realness of the past in the realm of Quantum Mechanics.

When engaging in contemplation on the complex nature of existence, it becomes necessary to reflect upon the significant implications that emerge when examining the connection between an observer and the unfolding events (Besnard, 2018, p.17). Furthermore, as we venture into the mysterious domain of the future, we are confronted with the bewildering concept that it possesses an inherent openness, defined by its metaphysical indeterminacy. Thus, one may posit that the elusive grandeur of the future relinquishes its existence for an observer confined within the boundaries of the present moment. In deep contemplation, I have arrived at a profound realization: the philosophical concept of Possibilism, which posits that the past exists in actuality while the future manifests as a realm brimming with myriad possibilities rather than predetermined certainties, beautifully resonates with the foundational tenets of Quantum Mechanics.

I also firmly argue that the acceptance of the Many-world interpretation, in contrast, renders quantum physics incompatible with Possibilism. The lack of compatibility between the Many-Worlds Interpretation and Possibilism arises from inherent disparities in their foundational beliefs. The Many-Worlds Interpretation proposes the existence of a vast multitude of parallel universes, each representing different potential outcomes, hence questioning the notion of a predetermined past. The Many-Worlds paradigm postulates that all possible possibilities are actualized and coexist concurrently inside separate realities. The aforementioned remark introduces a contradiction to the theoretical framework of a growing block universe, which postulates that the past is fixed and unchangeable.

Moreover, the concept of the Growing Block Universe postulates the presence of temporal asymmetry, whereby the ongoing expansion of the present is shaped by potential future states. From this perspective, one may argue that the cosmos does not possess predetermined outcomes, hence permitting a wide range of conceivable events to unfold in the future. However, the Many-Worlds Interpretation eliminates the concept of a unique growing universe based on a certain timeline. The argument posits that the coexistence of all potential outcomes simultaneously challenges the notion of a future path, as proposed by the Growing Block Universe concept, so rendering it incompatible with the Many-Worlds Interpretation.

References

Anderson, E. (2017). The Problem of Time: Quantum Mechanics Versus General Relativity (Vol. 190). Springer.

Aristotle, Physics, (2013). Written 350 B.C.E, Translated by R. P. Hardie and R. K. Gaye the Internet Classics Archive Physics by Aristotle, part 10.

Aspect, A. (1999). Bell's inequality test: more ideal than ever. Nature 398, 189–190. https://doi.org/10.1038/18296

Ballard, K. E. (1960). Leibniz's Theory of Space and Time. Journal of the History of Ideas, 21(1), 49–65. https://doi.org/10.2307/2707998

Barnes, E., & Cameron, R. P. (2011). BACK TO THE OPEN FUTURE. Philosophical Perspectives, 25, 1–26. http://www.jstor.org/stable/41329461

Bertolami, O. (2022). The Physics of Time: Current Knowledge and Unanswered Challenges. http://arxiv.org/abs/2208.13737

Besnard, F. (2011, April 23). Time of Philosophers, Time of Physicists, Time of Mathematicians. arXiv.org. https://arxiv.org/abs/1104.4551

Borghi, C. (2018). A critical analysis of the concept of time in physics. ArXiv [Physics. Gen-Ph]. Retrieved from http://arxiv.org/abs/1808.09980

Bostock, D. (1980). Aristotle's Account of Time. *Phronesis*, *25*(2), 148–169. http://www.jstor.org/stable/4182090

Butterfield, J. (2012). On Time in Quantum Physics. Retrieved from http://philsci-archive.pitt.edu/9287/

Carroll, S. [Big Think]. (2023, January 27). The mind-bending physics of time. [Video]. YouTube. https://www.youtube.com/watch?v=AZsmyTE3j9o&t=29s

Carroll, Sean. (2012). Mysteries of Modern Physics: Time. THE GREAT COURSES Corporate Headquarters 4840 Westfields Boulevard, Suite 500 Chantilly, Virginia 20151-2299.

Curtis, B., & Robson, J. (2016, February 11). A Critical Introduction to the Metaphysics of Time. Bloomsbury Academic.

Dainton, B. (2016, April 15). *Time and Space*. Routledge.

d’Espagnat, B., & Zwirn, H. (Eds.). (2017, May 16). The Quantum World: Philosophical Debates on Quantum Physics. Springer. https://doi.org/10.1007/978-3-319-55420-4

Dempsey, P. (2013). On the Compatibility of Presentism and our most fundamental Physics. [Unpublished doctoral thesis]. University of Sydney.

Deng, N. (2018). Time Metaphysics of Routledge Encyclopedia of Philosophy https://doi.org/10.4324/9780415249126-N123-3

Dieks, D. (1991, November 1). Time in special relativity and its philosophical significance -.https://doi.org/10.1088/0143-0807/12/6/002 https://www.researchgate.net/publication/231140866_Time_in_special_relativity_and_its_philosophical_significance .

Evans, J., & Thorndike, A. S. (Eds.). (2006, October 1). Quantum Mechanics at the Crossroads: New Perspectives from History, Philosophy and Physics. https://doi.org/10.1604/978354032663210.1007/978-3-540-32665-6

Forrester, Rochelle (2017). The Philosophy of Perception - an Explanation of Realism, Idealism and the Nature of Reality.pdf. figshare. Journal contribution. https://doi.org/10.6084/m9.figshare.4752988.v1

Fox, M. (1970). Leibniz’s Metaphysics of Space and Time. Studia Leibnitiana, 2(1), 29–55. http://www.jstor.org/stable/40693580

Gale, R. M. (1968). The Language of Time. Lon- don: Routledge and Kegan Paul.

McTaggart, J. M. E. (1908). “The Unreality of Time”, Mind 17: 456–473..

Gao, S. (2019). The measurement problem revisited. Synthese, 196(1), 299–311. https://www.jstor.org/stable/48704132

Gleiser, M. (2019, February 14). No Such Thing as “Now” | ORBITER. ORBITER. https://orbitermag.com/no-such-thing-as-now/

Greene, B. (2004, February 1). The Fabric of the Cosmos: Space, Time, and the Texture of Reality. Vintage. https://doi.org/10.1604/9780375727207

Greene, B. [Science Time]. (2022, July 9). The Science of Time Explained by Brian Greene. [Video]. YouTube. https://www.youtube.com/watch?v=dNbrI18BOAI

Gribben, John. (1995) Schrodinger's Kittens, Phoenix: London

Hawking, Stephen, 1942-2018. (1998). A brief history of time. New York: Bantam Books.

Hughes, A. (2019). Special-Relativity-Vs.-Presentism. - https://bpb-us-e1.wpmucdn.com/journeys.dartmouth.edu/dist/f/4868/files/2020/02/Alex-Hughes-23-PHIL-1.08-Special-Relativity-Vs.-Presentism-and-Markosians-Reply-Final.pdf

J. Ellis McTaggart. (1908). The Unreality of Time. Mind, 17(68), 457–474. http://www.jstor.org/stable/2248314.

Karpenko, Ivan A. (2016) What is Time in Modern Physics? Epistemology and Philosophy of Science, Vol. 49, No. 3, pp. 105124.

Liu, C. (1993). The Arrow of Time in Quantum Gravity. Philosophy of Science, 60(4), 619–637. http://www.jstor.org/stable/188191

Ma, Hongbao. (2003). The Nature of Time and Space. Nature and Science Big Bang Timeless World Determinism. https://www.researchgate.net/publication/339252556_The_Nature_of_Time_and_Space

Mach, E. (1960). The science of mechanics (3rd ed.). T. J. McCormack (Trans.). LaSalle, IL: Open Court. (Original work published 1883)

Mariani, C., & Torrengo, G. (2021). The indeterminate present and the open future. Synthese, 199(1–2), 3923–3944. https://doi.org/10.1007/s11229-020-02963-y

Mittelstaedt, P. Weingartner, P.A. (2005). Laws of Nature. Springer-Verlag Berlin Heidelberg, Germany.

Muller, R. A. (2016). *Now: The Physics of Time*. W. W. Norton & Company.

Newton's Views on Space, Time, and Motion. (n.d.). Newton's Views on Space, Time, and Motion (Stanford Encyclopedia of Philosophy/Spring 2022 Edition). https://plato.stanford.edu/archives/spr2022/entries/newton-stm/

Notomi, N., & Kanazawa, O. (2018). Plato on Time and Eternity: Timaeus 37C-38C.

Parmenides (Stanford Encyclopedia of Philosophy/Winter 2020 Edition). (2020, October 19). https://plato.stanford.edu/archives/win2020/entries/parmenides/

Plato's Timaeus (Stanford Encyclopedia of Philosophy). (2022, May 13). https://plato.stanford.edu/entries/plato-timaeus/

Power, Sean. (2021). Philosophy of Time: A Contemporary Introduction. https://www.researchgate.net/publication/350395015_Philosophy_of_Time_A_Contemporary_Introduction

Qureshi-Hurst, E. and Pearson, A. (2020), Quantum Mechanics, time, and theology: indefinite causal order and a new approach to salvation. Zygon®, 55: 663-684. https://doi.org/10.1111/zygo.12621

Riggs, P. J. (2015). Contemporary concepts of time in western science and philosophy. In Long History, Deep Time: Deepening Histories of Place. doi:10.22459/lhdt.05.2015.03.

Riggs, P. J., McGrath, A., & Jebb, M. A. (2015). Contemporary Concepts of Time in Western Science and Philosophy. In Long History, Deep Time: Deepening Histories of Place (pp. 47–66). ANU Press. http://www.jstor.org/stable/j.ctt183q3h5.10

Rovelli, C. (2011) "Forget time". Found Phys 41, 1475 -1490. https://doi.org/10.007/s10701-011-9561-4

Rovelli, C. (2018, May 8). The Order of Time. Riverhead Books.

Savitt, S. (2014). "Being and Becoming in Modern Physics", The Stanford Encyclopedia of Philosophy, Edward N. Zalta (ed.). https://plato.stanford.edu/archives/sum2014/entries/spacetime-bebecome/

Smirne, A., Bassi, A. (2015). Dissipative Continuous Spontaneous Localization (CSL) model. Sci Rep 5, 12518. https://doi.org/10.1038/srep12518

Thébault, K. P. (2021, October). On Mach on time. Studies in History and Philosophy of Science Part A, 89, 84–102. https://doi.org/10.1016/j.shpsa.2021.08.001

Time Is of the Essence. . . or Is It? (2015, August 6). YouTube. https://www.youtube.com/watch?v=N-NTXoYTvao

Uffink, J. (2001). Bluff your way in the second law of thermodynamics. ArXiv [Cond-Mat.Stat-Mech]. Retrieved from http://arxiv.org/abs/cond-mat/0005327

Welch, K. (n.d.). Physics of Time. (PDF) Physics of Time | Kerri Welch - Academia.edu. https://www.academia.edu/3777331/Physics_of_Time

Wheeler, J. A., & Zurek, W. H. (Eds.). (1983). Quantum Theory and Measurement. Princeton University Press. http://www.jstor.org/stable/j.ctt7ztxn5

Zeh, H.D. (2009). Time in Quantum Theory. In: Greenberger, D., Hentschel, K., Weinert, F. (eds) Compendium of Quantum Physics. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-540-70626-7_221.

Zeno's Paradoxes. (n.d.). Zeno's Paradoxes (Stanford Encyclopedia of Philosophy/Winter 2019 Edition).