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Original Paper

A Dialectical Interpretation of Quantum Mechanics

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Abstract: The double slit experiment suggests that particles combine characteristics of particles and characteristics of waves, and the act of observing or measuring a quantum system has an effect on the system. How that happens constitutes the measurement problem of quantum mechanics. As Richard Feynman was fond of saying, all of quantum mechanics can be gleamed from carefully thinking through the implications of this single experiment. There is another interpretation of quantum mechanics that has not been considered. When a quantum system is observed or measured, something else occurs simultaneously. Relativity, that is the specific point in time and space from which the observation or measurement occurs, is introduced into the quantum system. A dialectical interpretation of the double slit experiment suggests that particles and waves exist simultaneously in a state of superposition because a quantum system exists independently of relativity, that is independently of any specific point in time and space which is what separates the different quantum states. It is only when relativity is introduced into the quantum system, that is the particle's state of existence at any specific point in time and space, that an observation can occur and the system collapses into one of the possible definite and measurable states. A dialectical interpretation of quantum mechanics is supported by replicating Schrodinger's thought experiment which remains the defining benchmark for modern interpretations of quantum mechanics. Set theory and an analysis of quantum dialectics will explain the process or mechanism responsible for the wave function collapse.

Keywords: quantum foundations, quantum measurements, quantum coherence and coherence measures, quantum-to-classical transition

1. Introduction

An interpretation of quantum mechanics is an attempt to explain how the mathematical theory of quantum mechanics corresponds to reality. Some of the most compelling achievements in the development of quantum theory, just a few of which are mentioned in the present paper, have contributed toward our current understanding and provided a path for future developments. Thomas Young created the basic idea for the now-famous double-slit experiment. Young demonstrated the principle of interference of light, a phenomenon in which two waves superpose to form a resultant wave of greater, lower, or the same amplitude. One of the most notable of his many achievements, Young established the wave theory of light which

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demonstrated that light acts as a wave. The basic double-slit setup Young proposed has since been used not only to show that light acts like a wave, but also to demonstrate that electrons can act like waves and create interference patterns. Through the work of Max Planck, Albert Einstein, Louis de Broglie, Arthur Compton, Niels Bohr, and many others, current scientific theory holds that all particles exhibit a wave nature and vice versa.

Introduced first by Werner Heisenberg, the Heisenberg's Uncertainty Principle is any of a variety of mathematical inequalities asserting a fundamental limit to the precision in which certain pairs of physical properties of a particle can be known. Heisenberg found that the more precisely the position of some particle is determined, the less precisely its momentum can be known, and vice versa. Because we cannot measure both the position and the momentum of a particle with precision, the most we can hope for is to calculate probabilities for where things are and how they will behave. Heisenberg concluded that these uncertainties or imprecisions in the measurement were a fundamental property inherent in quantum systems. Niels Bohr argued that the measuring device itself delivers random kicks to the particles that cause a fundamental change in its behaviour.

The most commonly held interpretation of quantum mechanics is the Copenhagen interpretation where a quantum system exists in all possible states at once until it interacts with or is observed by the external world, at which time the superposition collapses into one of the possible definite states. Devised by Bohr and Heisenberg, the Copenhagen interpretation states physical systems generally do not have definite properties prior to being measured, and quantum mechanics can only predict the probability distribution of a given measurement's possible results. The act of measurement affects the system, causing the set of probabilities to reduce to only one of the possible values immediately after the measurement.

The Copenhagen interpretation was challenged by Erwin Schrodinger's thought experiment in which a cat is placed hypothetically in a locked chamber, and the life or death of the cat depends randomly on the state of a radioactive atom and whether it decays and emits radiation. Schrodinger's thought experiment suggests that the cat's state inside the box must be and simultaneously cannot be both alive and dead at the same time. These findings continue today to defy logic and remain at the heart of our understanding of the universe.

In contrast to the role of an observer in quantum physics, the role of an observer in general relativity is quite different. In his book on relativity, Bernard Schutz sums up the idea of observers used in almost all treatments of standard special relativity, describing an observer as a huge information-gathering system, not simply one man with binoculars but a frame of reference from which a set of objects or events are being measured. In fact, we shall remove the human element entirely from our definition, and say that an inertial observer is simply a coordinate system for space-time, which makes an observation simply by recording the location (x,y,z) (x,y,z) and time (t) (t) of any event. Therefore, if that event is an observation or measurement, then it's collapse would occur through the specific point in time and space from which the observation or measurement occurs.

The relationship between a quantum system and relativity was uncovered by Klein (2018) in Quantum Physics, Relativity and a Grand Unified Theory, and the present paper builds on that prior research by applying set-theoretic concepts and a dialectical approach to explain the wave-particle duality. Thomas Kuhn noted a dialectical view figures in various theories of the development of science, and James Wells has documented a shift toward dialectical approaches in almost every natural science during the past 150 years. A dialectical interpretation of

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quantum mechanics provides a new explanation for the particle-wave paradox without the measurement problem and suggests new information about the relationship between quantum physics and relativity.

The standard model has been proven successful in unifying three of the four fundamental forces that govern matter in the universe: the weak nuclear force, the strong nuclear force, and the electromagnetic force. However, the standard model remains incompatible with the fourth known universal force, namely gravity, as described by Albert Einstein's theory of relativity. Stephen Hawking made an enormous first step toward unifying the standard model with relativity by observing them interact together at the edge of a black hole known as the event horizon. Hawking radiation lies at the center of a paradoxical problem. Hawking observed that black holes simultaneously create and destroy energy, emitting particles and energy in the form of radiation at an area of space-time surrounding a black hole where the gravitational pull is so strong that nothing should be able to escape.

Scientific paradoxes have their roots in mathematics and philosophy. Georg Wilhelm Friedrich Hegel is one of the greatest systematic thinkers in the history of Western philosophy. His concept of a paradox later came to be known as the Hegelian dialectic, an interpretative method in which a thesis is necessarily opposed by an equally contradictory antithesis, the contradiction being reconciled on a higher level of truth through a synthesis. Hegel identified three stages of development in the dialectical relationship. First, there is a thesis, giving rise to its reaction. The second stage is the development of an antithesis that, while sharing common traits, contradicts and opposes the thesis. These first two stages of Hegel's dialectic are consistent with Newton's third law of motion, a cornerstone of physics, which states that for every action, there is an equal and opposite reaction, and forces only occur in opposing pairs. The third stage of development in the dialectical relationship is that as two opposing forces come together, they create a distinct, new group that resolves the tension between them by means of a synthesis. This synthesis solves the conflict between the two opposing forces, namely the thesis and its antithesis, by reconciling their common truths and forming a new thesis, causing the process to begin again.

There are three paradoxical principles of dialectical relationships. First, two opposing forces can both be true. Everything comprises contradictions or opposing forces. According to the principle of polarity, reality is not static, but comprises opposing forces (a thesis and antithesis) from whose integration (synthesis*)* evolves a new set of opposing forces. Second, everything is separate and connected in some way. This is supported by quantum entanglement, a phenomenon in which atomic electrical particles, energy or waves are always meeting and becoming entangled with each other. According to the principles of interrelatedness and wholeness, each part of a system is of limited value unless the analysis of that system relates the part to the whole. Therefore, the identity of each part of a system exists and evolves relative to its interaction with each other part and relative to the system as a whole. Third, change is the only constant. Change is transactional with both forces affecting and influencing each other reciprocally. The tension between the thesis and antithesis forces within each system produces change. The new state following change (the synthesis) also comprises polar forces, and thus change is continuous.

A dialectical interpretation of quantum mechanics suggests that similar to a set of meshing gears transmitting rotational motion, apparently contradictory states or systems share a transactional relationship, and it is the conflict, tension and friction created between them that produces change. The new state following change (the synthesis) also comprises polar forces,

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and thus change is continuous. The gear model has been used throughout modern physics. James Maxwell used a gear wheel in his model of electromagnetism to explain the electric current as a rotation of particles in opposite directions to that of the rotating field lines. Quantum physics uses gears as a model for several different systems, such as artificially constructed nanomechanical devices or a group of ring molecules. The three-wave hypothesis compares the wave-particle duality to a bevel gear.

A dialectical approach offers an alternative to the Copenhagen's interpretation, one in which a quantum system exists in all possible states at once until it interacts with a specific point in space-time, at which time an observation can occur and the system collapses into one of the possible definitive and measurable states. The hypothesis that a quantum state is created through the time and space from which an event (such as an observation or measurement) occurs will be tested in two ways. First, Schrodinger's famous thought experiment will be replicated. Second, applying relationship theory and set theoretic concepts will establish a basic mathematical foundation that can be tested.

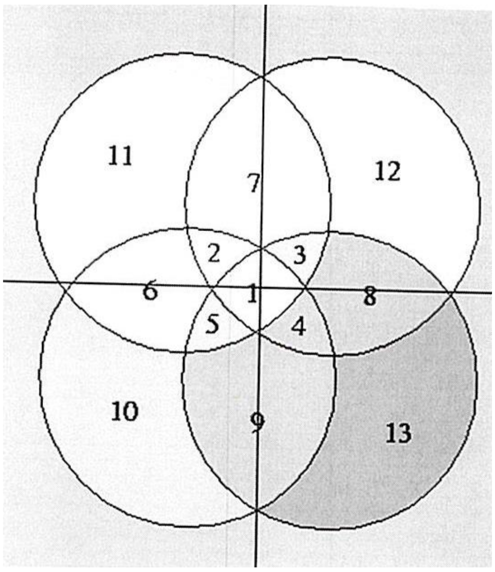
2. Methods

Schrödinger's cat is a thought experiment that illustrates what Erwin Schrodinger saw as the problem of the Copenhagen interpretation of quantum mechanics. In Schrödinger's thought experiment, a cat, a flask of poison, and a radioactive source are placed in a sealed box. If an internal monitor (e.g. Geiger counter) detects radioactivity (i.e. a single atom decaying), the flask is shattered, releasing the poison, which kills the cat. A dialectical interpretation of Schrodinger's experiment explains when and how the collapse occurs, allowing an accurate prediction as to whether the cat is alive or dead.

By applying mathematical relationship theory, a more defined relationship between relativity and quantum physics emerges. Many mathematical concepts can be defined precisely using only set-theoretic concepts. There are three justifications for this approach. First, set theory is a paradoxical model. Russell's paradox is the most famous of the many set-theory paradoxes. This paradox arises within naïve set theory by considering the set of all sets that are not members of themselves. Such a set appears to be a member of itself if and only if it is not a member of itself. From a particle being simultaneously a wave to the dilemma of Schrödinger's cat to the competing frameworks of quantum physics and general relativity, the theories that physicists have amassed over the centuries to explain our understanding of the universe are all ultimately paradoxical.[14] Logic dictates that the most effective way to understand a paradox is by applying a paradoxical model. The second justification for this approach is that the effectiveness of unifying contradictory states has been demonstrated through its application to other situations in physics in which two apparently contradictory concepts have been reconciled successfully. For instance, the electroweak force is created through a union between electromagnetic and weak interactions. Nuclear interactions are created through a union between strong and weak nuclear forces. Electromagnetism is created through a union between electric and magnetic charges. The third justification for this approach is that set theory is a branch of mathematical logic that studies the relationship between sets, particularly those that share commonalities. Quantum physics comprises energy and matter, and its energy contains speed ($E=mc^2$). Relativity comprises time and space, and its time contains speed (time=distance/speed). Speed is the one common trait or denominator between quantum physics and relativity. Set theory provides a mathematical explanation for a union of sets, namely a quantum system and relativity, which share the common, interlocking trait of speed while simultaneously maintaining opposing forces.

Everything in the universe comprises all or some of energy, matter, space, and time. As these four states come together, they create 13 possible states of reality: 1) all possible states at once; 2) space, matter, and time; 3) matter, time, and energy; 4) space, time, and energy; 5) matter, energy, and space; 6) space and matter; 7) matter and time; 8) time and energy; 9) space and energy; 10) space; 11) matter; 12) time; 13) energy. Figure 1 illustrates all possible logical relationships between a finite collection of sets, namely energy, matter, time, and space (Fig. 1).

Figure 1: All Possible States of Reality



In mathematics, the intersection of two sets, namely a quantum system and relativity, is the set that contains all the elements of quantum physics that also belong to relativity (or equivalently, all elements of relativity that also belong to quantum physics). In set theory, the union (∪) of a collection of sets is the set of all elements in the collection.

3. Results

A dialectical interpretation solves the dilemma posed by Schrodinger's cat in a box. Existence comprises the dialectically opposing states of life and death. They exist simultaneously in a state of superposition because a quantum system exists independently of relativity, that is, independently of any specific point in time and space which is what separates the various quantum states between life and death. It is when relativity is introduced, that is, the cat's state of existence at any specific point in time and space, that the system collapses (or evolves) into one of the many possible definite and measurable states. The state of Schrödinger's cat is created through a synthesis of common, interlocking truths between the evolving quantum state inside the closed box and any specific point in time and space. The cat's state of existence is

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created through and relative to the time and space from which an observer opens (or does not open) the box.

The relationship between a quantum system and relativity can be examined more closely by applying set theory. Each of the 13 possible states of reality is created through a union or synthesis of common, interlocking truths between opposing states. For instance, state 9 is created through a union or synthesis between space and energy. There are seven possible states that contain space (1, 2, 4, 5, 6, 9, and 10) and seven opposing states that contain energy (1, 3, 4, 5, 8, 9 and 13). The common traits between these two states are states 1 (all possible states), 4 (space, time and energy), 5 (matter, energy and space), and 9 (space and energy). Reconciling the common truths between the two results in space and energy.

State 3 is created through a union or synthesis between matter, time and energy. There are seven possible states that contain matter (1, 2, 3, 5, 6, 7 and 11), seven possible states that contain time (1, 2, 3, 4, 7, 8, and 12), and seven possible states that contain energy (1, 3, 4, 5, 8, 9, and 13). The common truths between these three states are states 1 (all possible states) and 3 (matter, time, and energy). Reconciling the common truths between these two states results in matter, time, and energy. The dialectical formula can be applied successfully to each state, demonstrating that all possible states are created through a union or synthesis of common, interlocking truths between opposing states.

For instance, time (T) and space (S) have a dialectical relationship, sharing common, interlocking truths (relativity) while simultaneously maintaining contradictory states. Similarly, energy (E) and matter (M) have a dialectical relationship, sharing common, interlocking truths (quantum physics) while simultaneously maintaining contradictory states. In this way, quantum physics (QP) and relativity (R) have a dialectical relationship, sharing common, interlocking truths while simultaneously maintaining contradictory states. (Fig. 2).

As a quantum system and relativity come together, they create a distinct, third group that resolves the tension between them by means of a synthesis. This synthesis solves the conflict between two opposing states by reconciling their common truths. Speed is the one common trait or denominator that links quantum physics and relativity. There are 10 possible states of reality that contain either energy or time and therefore contain speed.

As matter, energy, time and space intercept, quantum physics ($M \cup E$) becomes a set that contains 11 elements (nine states that contain speed, one state that contains space and matter, and one state of matter). Relativity ($T \cup S$) becomes a set that contains 11 elements (nine states that contain speed, one state that contains space and matter, and one state of space). Reconciling the states that contain the common trait of speed results in 10 possible states of reality coming together to form states 1, 2, 3, 4, 5, 7, 8, 9, 12 and 13. According to dialectical principles, reality is created through a union or synthesis of states that contain the common, interlocking trait of speed (Fig. 3).

Figure 2: Synthesis of Opposing States

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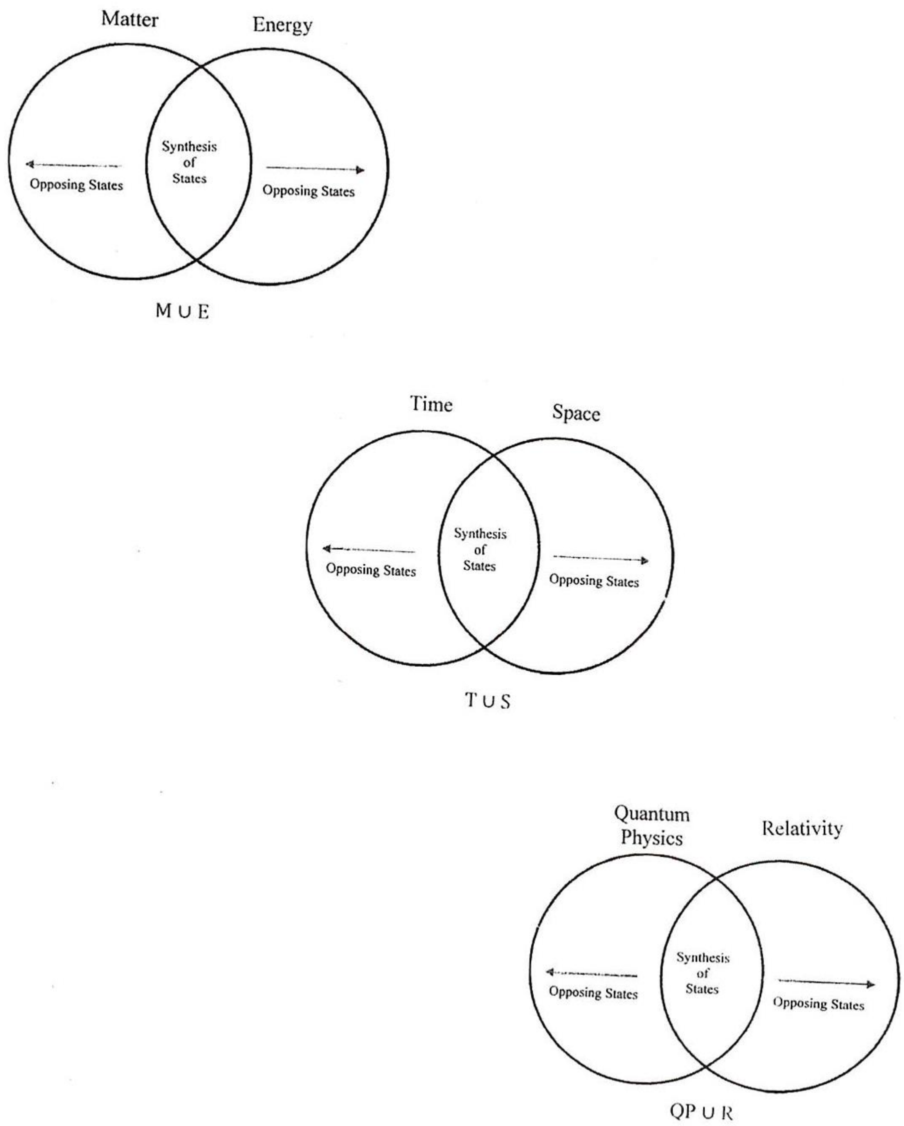
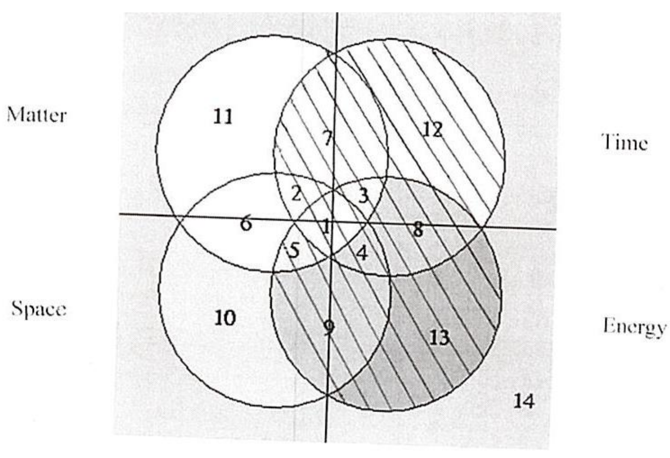


Figure 3: The Synthesis of States Containing Speed



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As illustrated in Figure 3, set theory suggests a basic mathematical formulation which describes the union of quantum physics and relativity as:

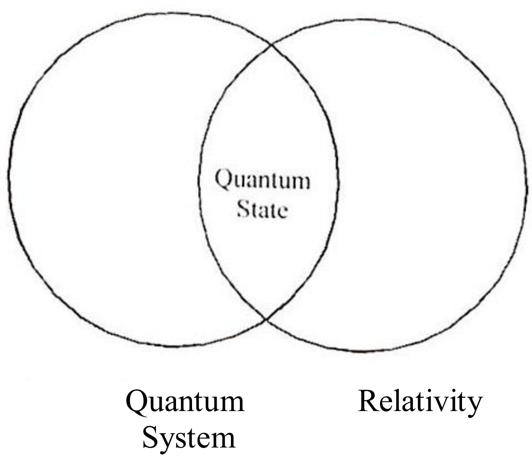
$$[[T \subseteq (M \cap T)] \cup [E \subseteq (S \cap E)]] \subseteq [M \cup E \cup T \cup S]$$

4. Discussion

According to Powell, the problem with combining quantum physics and relativity is that relativity gives nonsensical answers when scaled down to quantum size, eventually descending to infinite values in its description of gravity. Likewise, quantum physics runs into serious trouble when blown up to cosmic dimensions, piling so much energy in the quantum field that it creates a black hole that causes the universe to fold in on itself. The dialectical relationship, which excludes states 6, 10, and 11 from the synthesis, subtracts tiny particles of matter and huge gravitational fields of space, thereby bridging the gap between quantum physics and relativity.

A dialectical interpretation suggests that a quantum state is created through the interaction between a quantum system and the specific point in time and space from which an observation, measurement or some other event occurs (or does not occur). Objective reality is created through a specific point in time and space independent from an observer. Figure 4 shows how a particle can co-exist in a state of superposition (independent of relativity or any specific point in time and space which is what separates the different quantum states) and simultaneously as a quantum state (at any specific point in time and space, such as when an observation, measurement or some other event occurs). For instance, throughout space-time, the butterfly can exist as both a caterpillar and a butterfly. However, at any specific point in space-time, it can exist only as either a butterfly or a caterpillar. A collapse does not occur because it is seen or measured. The butterfly exists throughout space-time and simultaneously exists at a specific point in space-time.

Figure 4



(quantum state) = (quantum system) (x,y,z) (x,y,z) (t) (t)

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This interpretation of quantum mechanics is largely compatible with alternative interpretations of quantum mechanics and the physical realization (correspondence between theory and experiment) of quantum mechanics with some key differences. In particular, we will argue this point from three viewpoints: quantum decoherence[31], GRW theory[32], and the classical Copenhagen interpretation[33].

Dialectic quantum mechanics is most compatible with quantum decoherence. Here quantum decoherence argues that quantum states are never in perfect isolation, but rather interact with the rest of the universe, which breaks the any initial eigenstate or superposition of eigenstates. This results in eigenstate mixing which is analogous to weak and strong wave turbulence theory and drives a wave description of a particle to a statistical description of a particle over a long enough timescale. Indeed a dialectical interpretation of quantum mechanics argues that such pure eigenstates are never pure and by definition will mix over its evolution in spacetime. Measurements are regions of enhanced interaction that breaks these pure energy/measurement eigenstates.

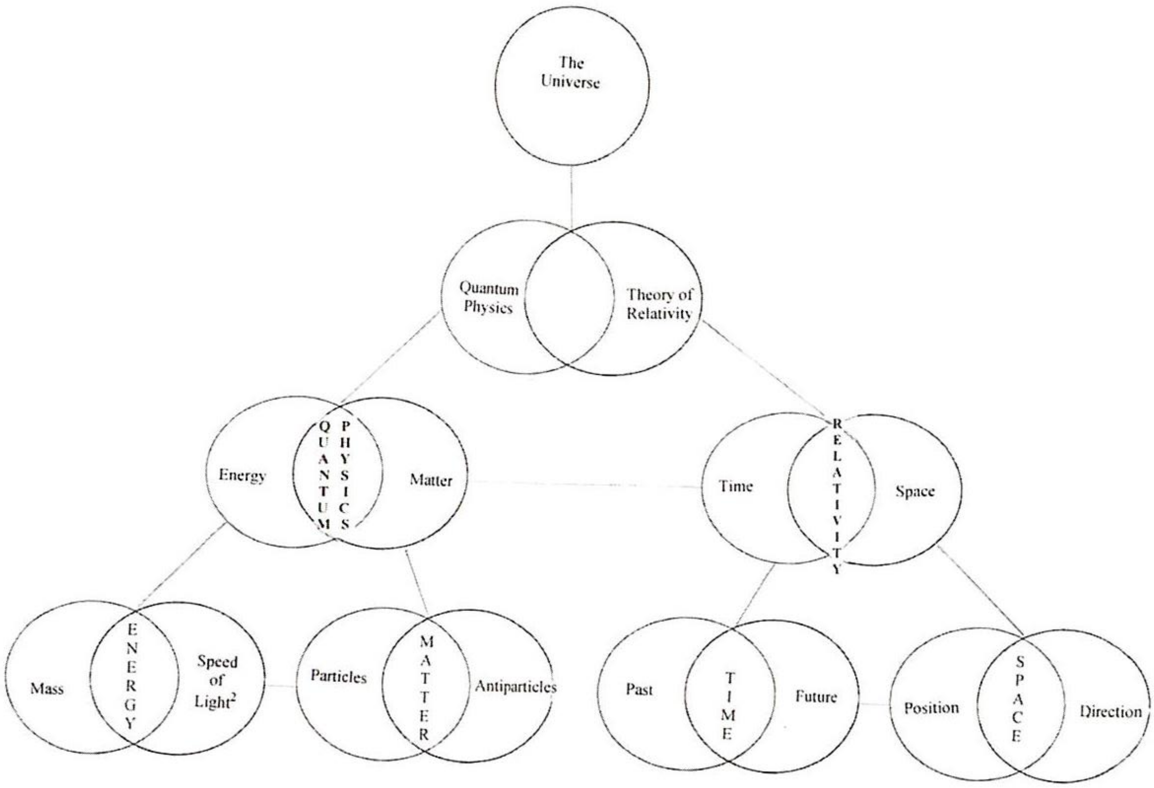
Next, we compare our interpretation of quantum mechanics to collapse theories like GRW theory.[32] Here again, we find correspondence as GRW theory posits that collapse of quantum states are only possible went an interaction between a pure state interacts with a large number of other pure states, e.g., measurements. Again dialectical quantum mechanics is compatible with this theory as it is only relevant for pure quantum states when an interaction with other states is weak. Unlike GRW theory, we are agnostic as to how the ultimate collapse of the wavefunction occurs as mathematically such an effective collapse must occur. On the other hand, we merely require that a strong deviation in the evolution operator (Hamiltonian) is produced via interactions with the rest of the universe at a measurement point. As the collapse is produced by a perturbed Hamiltonian, all measurements are by definition unitarity preserving (for the entire state, not the pure state).

Finally, we comment on the relation between dialectical quantum mechanics and the classical Copenhagen interpretation.[33] The major issue with the classical interpretation is that it gives special weight to the nature of measurement operators. It is both unclear how such operators are produced, how unitarity is guaranteed in their formulation, and how these measurement operators operate on particles in reality. Our interpretation, while compatible with the idea of measurement induced wavefunction collapse, prescribes a precise manner in which this collapse would occur. In particular, collapse to a measurement eigenstate will occur due to interaction with the rest of the universe are particularly strong particular space-time point, e.g., at a measurement. Our interpretation guarantees unitarity and removed the arbitrary nature of the measurement operator in the Copenhagen interpretation in favor of strong nonlinear interactions (governed by a perturbing Hamiltonian) at a particular space-time point.

Consistent with the principles of Hegel's dialectic, quantum physics and relativity have a paradoxical relationship because they (i) oppose each other ***and*** synthesize together, (ii) are each separate states ***and*** parts of a greater whole, and (iii) are incompatible with each other ***and*** share a continuous, transactional relationship. Similar to a small and large-scale set of meshing gears transmitting rotational motion, quantum physics and relativity, respectively, share a transactional relationship, and it is the conflict, tension and friction created between them that produces change. The new state following change (the synthesis) also comprises polar forces, and thus change is continuous.

A dialectical interpretation of the universe suggests that everything is created through a union between apparently contradictory states. Matter and energy synthesize together to create quantum physics. Time and space synthesize together to create relativity. The past and future synthesize together to create present time. Particles and antiparticles synthesize together to create matter. Position and direction synthesize together to create space. Mass (an objects resistance to motion) and the speed of light² (a state of motion) synthesize together to create energy. These relationships present a pattern that suggests how everything in the universe is connected to create our reality (Figure 5).

Figure 5: Dialectical Forces of the Universe



On the one hand, existence is created through the synthesis of common, interlocking truths between a quantum system and relativity. On the other hand, reality is a paradox created through a union or synthesis of common, interlocking truths between dialectically opposing objective and subjective states of reality. For instance, if a tree falls in a forest and no one is around to hear it, then the synthesis of common, interlocking truths between objective and subjective states of reality is, "A tree falls in a forest, and no one is around to hear it." A synthesis of common, interlocking truths creates a *higher* truth. Objective and subjective reality have a dialectical relationship because they (i) oppose each other ***and*** synthesize together, (ii) are each separate states ***and*** parts of a greater whole, and (iii) are incompatible with each other ***and*** share a continuous, transactional relationship. Truth is paradoxical. Contradictory truths do not cancel each other out or dominate each other but exist side by side (Fig. 6).

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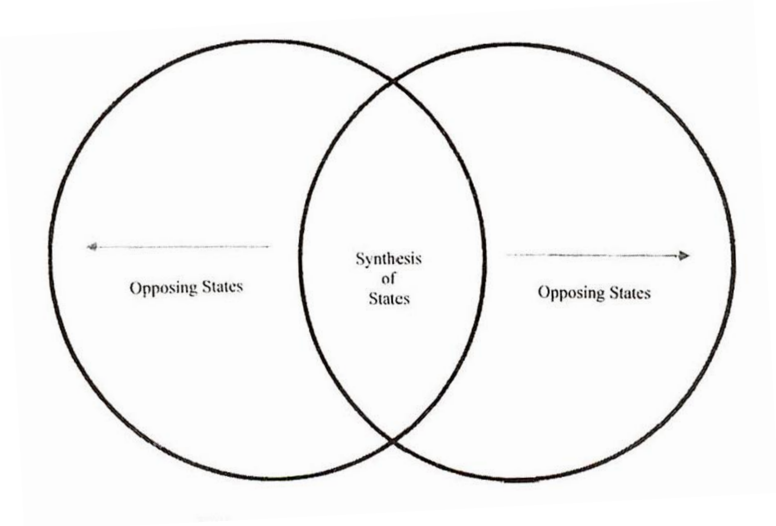
Figure 6: States of Reality



Objective Reality Subjective Reality

We each share a dialectical relationship with each other. Reality is created through the continuous synthesis of common, interlocking truths (beliefs) that we share with others**.** As common truths are reconciled, we form new groups or *higher* truths. Th**e** identify of each part of a system, namely each person's reality, exists and evolves relative to its interaction with each other part, namely every other person's reality, and relative to the system as a whole. We all exist within a spiral continuum of dialectical change. Reality is ever-changing, creating a ripple effect, and change is transactional with a cause and effect. In this way, each of us is a reflection and extension of each other and part of a greater whole (or truth). Everyone has her or his own separate truth. At the same time, reality is the synthesis of common, interlocking truths and is what connects us to each other.

According to dialectical principles, the universe is simultaneously infinite (in its quantum state of superposition) and finite (at any specific point or realm of space-time). Life is created physically through the synthesis of common, interlocking truths between dialectically opposing male and female counterparts. Although beyond the scope of the present paper, other planes of existence are created through the dialectical relationship, and those different planes share a dialectical relationship with each other. For instance, the mental plane exists through a union or synthesis of common, interlocking truths between dialectically opposing physical and spiritual planes of existence.

When, as in fields such as quantum physics and relativity theory, existing assumptions about reality have been shown to break down, this has usually been dealt with by changing our understanding of reality to a new one that remains self-consistent in the presence of the new evidence.[35] Thomas Kuhn noted that the evolution of scientific theory does not emerge from the straightforward accumulation of facts but rather from a set of changing intellectual circumstances and possibilities.[10] A dialectical interpretation of quantum mechanics applies set theory to make the following predictions: (i) the union of quantum physics and relativity results in a synthesis of states that contains the common, interlocking trait of speed, (ii) quantum physics and relativity simultaneously oppose each other and synthesize together, (iii) this resulting conflict, tension and friction created between a quantum system and relativity produces change, (iv) the new state following change (the synthesis) also comprises polar

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forces, and thus change is continuous, and (v) whether Schrödinger's cat is alive, dead, or both. Notwithstanding the need for additional, rigorous research, a dialectical interpretation offers a theoretical and mathematical model that solves the measurement problem of quantum mechanics, links quantum physics and relativity, and creates a paradigm for future studies in unified field theory.

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