2022

Parallels of Quantum Mechanics and Mahāyāna Buddhist Philosophy: An Argument for Relational Quantum Mechanics

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Parallels of Quantum Mechanics and Mahāyāna Buddhist Philosophy:

An Argument for Relational Quantum Mechanics

A Thesis Presented

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To the Keck Science Department

of

Claremont McKenna, Scripps, and Pitzer Colleges

In Partial Fulfillment of

The Degree of Bachelor of Arts

Senior Thesis in Physics and Philosophy

[4/25/22]

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Abstract:

Western orthodoxy philosophy is based on the principle of noncontradiction and thus, the philosophy of science is as well. The most prominent interpretations of quantum mechanics, since its inception, have followed this principle. In this paper, two quantum phenomena, the Observer Problem (measurement problem) and quantum entanglement will be analyzed from a Mahayana Buddhism ontological perspective. I will analyze the mathematical and philosophical arguments proposed by Graham Priest and Jay Garfield, based on dialethism, pertaining to Nagarjuna and the Net of Indra. Demonstrating the parallels and adaptability of the arguments to further the philosophical groundwork for Carlo Reveille's Relational Quantum Mechanics (Rovelli, 1996), as a novel interpretation that can be taken with more weight against its non-contradictory heavyweights.

Introduction:

The analytical component of physics is undoubtedly a crucial aspect of the practice and every day, new experimental advancements are made in lieu of its core principles and formalities. The principles that guide the mathematics and analytics of physics, specifically quantum mechanics, will influence the formalities of our reality and principles of the universe going forward into the future and the way we do physics. Hence, it is important that physicists and philosophers of physics scrutinize the current status quo and reinterpret the methodology and principles of quantum mechanics to make sure that as scientists, we are not robbing ourselves of potential interpretations that could aid in the advancement of quantum mechanics. Even now we have seen that the measured anomaly at the Fermi National Accelerator Laboratory, could signify the existence of error in the Standard Model, or there exist elementary particles we have not detected (Grainger College of Engineering, Fermilab, 2021). Thus, our theories of the physical world are only so true, in consensus, as they work in the real world.

Indian and Buddhist philosophy has influenced Western thought around the philosophy of quantum mechanics since the early 1970s with the publication of *The Tao of Physics: An exploration of the Parallels between Modern Physics and Eastern Mysticism* by physicist Fritjof Capra. Capra explored the parallels between Eastern mysticism and the theories of Quantum Mechanics (QM), bringing forward a holistic interpretation of QM from a linear mechanical one (Capra, 1975). Since then, many scholars have dismissed the notion of relating Eastern philosophy to quantum mechanics, as it falls short of providing any real value to the field. Yet, in recent years individuals have given respect to certain philosophical thoughts that have often been dismissed, that of Ludwig Wittgenstein and of ancient Buddhist thinker Nāgārjuna (Demont-Biaggi, Florian).

In this paper, I will be furthering the comparisons and cross-examination of ancient Buddhist philosophy, most notably that of Mahāyāna Buddhism and Nagarjuna's, paired with philosophical interpretations by Graham Pries and Jay Garfield to our current understanding of quantum entanglement and the observer problem. The systems that exist in these philosophies, I argue, can be normative and systematically applicable not only on metaphysical and ontological philosophical grounds but applicable to the philosophy of quantum mechanical science. If these systems work in our causal reality, then they can be the groundwork to build principles and methodologies, when trying to interpret quantum systems and progress the field from antiquated methodologies of thought. Hoping to provide metaphysical and epistemic grounds for Carlo Reveille's Relational Quantum Mechanics as a potential theory to support, considering the parallels and modalities found in Buddhist philosophical systems.

Ch. 1: Quantum Mechanical Phenomena

(1.1) The Observer Problem:

In modern physics, specifically Quantum Mechanics (QM), the *observer effect*, has been an integral part of QM and an issue that remains to be solved. The Observer Problem, as it will be referred to from now on, can be best described by the infamous “double-slit experiment.” The experiment goes as follows; Many particles (electrons) pass through a double-slit wall; the particles are left to strike a particle detector. In this experiment, Thomas Young, the first to observe the phenomena, observed an interference pattern from the particle detector, reminiscent of an interference pattern for a wave. When one slit was used, the pattern produced was as expected, yet when two slits were used, the resulted pattern was that of a waveform interference pattern (Myrvold, 2022).

The results do not seem to make sense in a classical view, as now an issue arises; how can smatter behave like a wave? Further imitations of the experiment were conducted, with the modification of implementing a measurement device to observe which slit the particles exited from. In these experiments, the mere act of placing a measurement device, an observer, affected the interference pattern shown. Instead of acting as a wave and expecting a wave interference pattern, the physicist observed just two bands in which the particles strike, as expected from a particle in one slit. These contradicted the previous results, hence there must be a connection between the act of taking a measurement and the resulted interference pattern.

The observer effect in practical terms is the mere act of observing a possible outcome that will collapse the wavefunction of a particle into a single outcome, that is, when the particle is not observed, it behaves as a wave. When acting as a wave then all possible outcomes, that is all possible measurements that can be made are in superposition with one another. If that is the case, then the wavefunction of the particle is both at all possible outcomes and at the same time not at all possible outcomes, as it will lock into one possible measurement when an observer makes a measurement. In other words, when observed the wave collapses, and one state is chosen in the observation of the system. This gave rise to the field of quantum mechanics and the furthered development of the physics and mathematics that represent the quantum effects seen in the experiment performed by Young.

In mathematics, this wave-particle duality is represented by the Schrodinger equation. The Schrodinger equation describes the time-evolution of a wave in a system, and it can be used to analytically predict the general probability of events or outcomes in a system. The wavefunction was formulated by physicist Erwin Schrodinger in 1926; the equation is as follows (Nave. R, 2017):

$$i \cdot \hbar \cdot \frac{d}{dt}\left(\psi(x,t)\right) := \left[-\frac{\hbar^2}{2 \cdot m} \cdot \frac{d^2}{dx^2} + V(x,t)\right] \cdot \psi(x,t);$$

Here a wave function is defined by, $\psi(x,t)$; where it uses complex numbers for ***x*** and ***t*,** position, and time, respectively. The variable ***m*** represents the mass of the particle, ***i*** is an imaginary number, ***h*** represents the Planck constant, and *V* ***(x, t)*** is the potential of the environment of the particle in the system.

Later, the Schrodinger equation came to be defined, as vectors belonging to a Hilbert Space. A Hilbert Space generalizes mathematics (calculus and linear algebra) to cater to systems with an indefinite number of dimensions. The vector described is normalized in the Hilbert Space's inner product, so much so that in Dirac notation, $\langle \psi, \psi \rangle = 1$(Nave, 2017).

Physical observables: momentum, position, energy, and spin can be represented by Hermitian linear operators affecting the Hilbert Space. In measuring such observables, the wave function can be represented by an eigenvector of a desired observable (i.e., momentum, position, energy, spin operators). These are called eigenstates of the system and each eigenvalue relates to the observable value of the eigenstate and a quantum superposition of a system. These will be a linear combination of the eigenstates. When an observable is observed, the Born rule, that is, the probability density of a particle at a specific point is proportional to the square of the magnitude of the wavefunction of the particle at that specific point. The evolution of a Schrodinger equation can then be described by the derivative of the state vector of the system equal to its Hamiltonian operator acting on the state vector (Nave, 2017).

Most physicists would reconcile the Observer Problem with Born's Rule, as the calculated probabilities using the square of the wavefunction result in probabilities that are real, even if the wavefunction is complexed valued. The real probabilities are accurate enough in the results and would constitute the measurement of the system and have been proven mathematically and imply that the observer problem is solved sufficiently by this method of measurement.

Yet, the Observer Problem (OP), is not fully remedied by Born's Rule. It falls short in the physical realm beyond the simple and classical models of QM. The Observer Problem can be best described by Wayne Myrvold as the following:

1. A physicist is conducting an experiment on a quantum system, the system can have at least two distinguishable states, $|0\rangle_S$ and state $|1\rangle_S$
2. The scientist is utilizing an apparatus to conduct a measurement, the apparatus is in a ready state of measurement represented by $|R\rangle_A$ this is the observer.

3. The system, represented by the quantum system and the measuring apparatus should yield the following evolution.
    a. $|0\rangle_S|R\rangle_A \rightarrow |0\rangle_S\,|"0"\rangle_A$ and $|1\rangle_S|R\rangle_A \rightarrow |1\rangle_S\,|"1"\rangle_A$ (1 and 2)
4. If the system in now prepared in a superposition state, that is, $||\psi\,(0)\rangle_S = a|0\rangle_S + b|1\rangle_S$ where a and b are non-zero variables, the evolution of the predicted measurement by the linear Schrodinger equation will yield.
    b. $|\psi\,(0)\rangle_S|R\rangle_A \rightarrow a|0\rangle_S|\text{"0"}\rangle_A + b|1\rangle_S|\text{"1"}\rangle_A$.
5. This is not an eigenstate of $|R\rangle_A$ but rather an entanglement of the observer and the quantum system.
6. The eigenstates of the system and eigenvalues do not result in definite measurements of the apparatus reading, thus not consistent with that of the observer (3,4, and 5).
7. If Quantum Mechanics serves to be a universal physical theory, it should be applicable to physical systems
8. If the resulted measurement of the physicist is not consistent with the Schrodinger equation, then it is not a complete interpretation for physical quantum mechanical systems, thus, the observer problem is presented (6 and 7).

(Myrvold, 2022)

Wayne Myrvold's formulation of the observer problem is key in highlighting the issue of what happens in experimental results and the expected results stemming from the mathematics of quantum physics. The misalignment of the methods of measurement doesn't yield the results observed, thus there must be something missing in the physics of Q.M to account for the discrepancies seen or it is not an accurate representation of the quantum system at play.

In premise 4, by taking the description of the quantum system to be represented by the quantum state and following the evolution described by the Schrodinger equation, the outcomes of the evolution do not align with the outcomes produced, as seen by the measurements taken in the experiment. If the quantum description of the system is not complete or it is not correct then something must be done, for if by premise 7, quantum mechanics serves to be a descriptive theory of the physical world that is applicable universally, then it must be so that Q.M may be applied to experiments in the physical world, that yield an accurate description of the quantum physical world we inhabit.

Many approaches have been formulated to address the issue, with many falling under the three classifications provided by Myrvold. I will not describe all the approaches that currently exist, as that would take a lot longer of an essay, but I will describe the classifications produced by Myrvold:

1. "There are approaches that involve a denial that a quantum wave function (or any other way of representing a quantum state) yields a complete description of a physical system."
2. “There are approaches that involve modification of the dynamics to produce a collapse of the quantum state in proper circumstances.”
3. “There are approaches that reject both horns of Bell’s dilemma and hold that quantum states always undergo unitary evolution and that a quantum state-description is, in principle, complete.”

(Myrvold, 2022)

The classifications provided employ different interpretations, ranging from rejection of the quantum wave function to those who seek to add to the theory and those who believe the quantum state description to be complete. I will later in this essay, provide a possible interpretation, on philosophical grounds of Buddhist philosophy considering novel interpretations of quantum mechanics.

(1.2) Quantum Entanglement:

In 1935, Albert Einstein along with his postdoctoral research associates, Boris Podolsky and Nathan Rosen, published a paper titled, "Can Quantum Mechanical Description of Physical Reality Be Considered Complete?" (Einstein *et al.* 1935). This was published under the *Physical Review* and sparked a debate in the interpretations of quantum mechanics that is still ongoing to this day (Fine, 2020).

In this paper, Einstein, Rosen, and Podolsky prepared two particles in a configuration of a quantum state that is not a mixture of the states, a probability distribution of other 'pure' states, or that each particle cannot be reduced to a 'pure' state individually (Bub, 2020). They saw that when the particles move apart and they took a measurement in position, the measurement would match the outcome of the measurement of the other particle. This is true for either a positional or momentum measurement, yet only one measurement can be performed, not both, as then there would not exist a correlation between the measurement's values taken of the particles (Bub, 2020). Rosen, Einstein, and Podolsky argued that the quantum representation of a system is currently incomplete due to the absence of "*common causes"* or *"elements of reality"* (Bulb,2020). This is because the behavior exhibited in the correlation is that of the behavioral correlation in classical mechanics. The interaction can be described by '*common causes'* or '*elements of reality'* (Bub, 2020). Hence, the theory is not complete in representing the physical reality of real-world systems, in parallel to the Observer Problem told in the previous section (Bub, 2020).

This problem presented by the three physicists prompted Erwin Schrodinger to respond and can be best described in his words:

> "Yet since I can predict either x1 or p1 without interfering with the system No. 1 and since system No. 1, like a scholar in an examination, cannot possibly know which of the two questions I am going to ask first: it so seems that our scholar is prepared to give the right answer to the first question he is asked, anyhow. Therefore [,] he must know both answers; which is an amazing knowledge; quite irrespective of the fact that after having given his first answer our scholar is invariably so disconcerted or tired out, that all the following answers are 'wrong' (Schrödinger, 1935; p. 559: Bub, 2020)."

The fact that the particles in the experiment performed by Einstein, Rosen, and Podolsky demonstrated a correlation between the measurements of position or momenta as conjugate pairs, shows that there must exist an infinite amount of position or momenta operators with matching casual correlations regarding the conjugate pair of operators. Described by Schrodinger and Bub, the particle already exhibits information on the paired conjugate particles resulting in measurement in some form unknown to us (Bub, 2020). This is what Schrodinger coined, as '*entanglement*," and broadens the horizons of quantum mechanics, as to account for such physical qualia.

Quantum entangled particles also possess information that differs from the classical notion of information, as quantum information is represented by qubits. These qubits often hold "An arbitrarily large amount of classical information…This information can be processed and communicated but, because of the peculiarities of quantum measurement, at most one bit can be accessed (Bub, 2020)." These characteristics thus implied further research into the topic and Quantum information developed into its own study and has had practical applications aside from its exploration through academia, such as quantum computing and quantum information theory.

Ch. 2: Nagarjuna and Mahāyāna Philosophy

(2.1) Nagarjuna's Philosophy:

Nagarjuna is now known as the greatest and most important Buddhist Philosopher in history, with his philosophical work influencing and shaping the Buddhist traditions between 150-250 CE to this very day (Westerhoff, 2021). Nagarjuna differs from the Western philosophers in the sense that he himself takes unorthodox interpretations of contradictions and emptiness that would simply not work under a Western noncontradictory framework. Yet, for this reason, it is utterly important to not only interpret and analyze Nagarjuna's philosophy as philosophers, but as scientist as well. Jay Garfield and Graham Priest said it perfectly in their paper, *Nagarjuna and the Limits of Thought* (Priest & Garfield 2003):

> "Nagarjuna might appear to be an irrationalist by virtue of embracing some contradictions—both to Western philosophers and to Nyaya interlocutors, who see consistency as a necessary condition of rationality. But to those who share with us a dialetheist's comfort with the possibility of true contradictions commanding rational assent, for Nagarjuna to endorse such contradictions would not undermine but instead would confirm the impression that he is indeed a highly rational thinker."

In Western philosophy, many philosophers adopted the principle of noncontradiction and became a cornerstone of Western orthodoxy thought. The principle of noncontradiction states that contradictions cannot be true. This is a direct response to arguments for dialethism;

dialethism states that a contradiction can be true (Priest, 2017). In logical notation it can be represented as such:

(1)	A	P [1]
(2)	~A	P [2]
(3)	A & ~A	C [1,2]

Thus, the principle of noncontradiction would say the opposite and is common in the methodologies and systems that constitute how science is executed in Western and modern science. Aristotle was a big supporter of the principle of noncontradiction and gives a robust argument himself in *Metaphysics,* pushing it into Western thought and since then the argument itself has not had a modern formulation that keeps it bulletproof from concepts such as dialethism (Priest, 2010). Some Western philosophers did embrace the idea, that of David Hume, Hegel, Kant, Heidegger, and Wittgenstein, all of which work under the idea that contradictions can arise and can be invoked and can still be true and useful (Priest, Graham, and Berto, Francesco and Weber, Zach, 2018).

Nagarjuna, as previously said, subscribes to the idea of dialetheism, and will be further explained in this section. I will begin with an explanation of the two realities that exist under Nagarjuna’s terms, followed by an analysis of the *ultimate truth* and finally an explanation of the *one nature.*

(2.1.1) Two Realities = Two Truths:

Nagarjuna's arguments begin on the foundation of the *conventional* and *ultimate realities;* in these realities there exist two truths, these truths apply to the truth of *conventional reality* and the truth for *ultimate reality* (Priest & Garfield, 2003). Nagarjuna references the conventional reality as *samvrti-satya,* these truths are "truths concerning the empirical world (Priest & Garfield 2003)." Yet, they also conceal the truth, as *samvrti,* also means "concealing, hiding, obscuring, [or] occluding," and thus it can be best defined under the Madhayamaka tradition as (Priest & Garfield, 2003):

> "[S]uch truths conceal is precisely the fact that they are merely conventional (in any of the senses adumbrated above) or that an obscured mind is obscured precisely by virtue of not properly understanding the role of convention in constituting truth."

Nagarjuna does this to create a distinction between the conventional and the ultimate truths, in doing so, Nagarjuna gives *paramartha-satya:* the *"truth of the highest meaning* (Priest and Garfield, 2003)." In this distinction, the ultimate truth is properly understood, not by an *obscure mind,* but rather by a mind who can tell what the conventional truth is from the ultimate, as the discrepancies in the type of mind are often described in comparison as that of an *enlightened mind.*

This is where Nagarjuna's dialetheism comes into play, as one will see, Nagarjuna will demonstrate the contradictions of the two realities and the two truths, with a very distinct schema that seems foreign and outright a skeptic or a solipsist view, yet it holds its ground and leads to very interesting and true characteristics of our perceptive reality, as described in the following section.

(2.1.2) The Ultimate Truth and Emptiness:

The ultimate reality and thus, the ultimate truth is that *everything* is *empty*. By Western standards, this would not make sense, yet Nagarjuna employs precision in his justification for claiming so. He justifies this by his definition of what is emptiness, as Garfield and Priest put it, it is "emphatically not nonexistence but, rather, interdependent existence," which means existence cannot be an independent *essence* (Priest and Garfield, 2003). Essence relies on its interdependence with everything else; imagine a house, the essence of a house you might say is to live and inhabit, the house by itself has no essence. The essence is interdependent on that of people calling the house their home. Yet, the definition of what is the essence in Sanskrit is *svabhava*, "to have an essence…is for it to be what it is, in and of itself, independently of all other things (Priest and Garfield, 2003)." If this is what essence is and Nagarjuna is claiming that everything is empty, then it would imply that everything has no essence. If nothing does truly have no essence, then it is logical to say that everything is in fact empty, as contradictory and unorthodoxy as it may sound, it is a true statement by Nagarjuna's schema of thought.

The interdependence of existence ensures that there is no essence independent of itself and if there is no essence independent of itself, it means that everything is empty. So much so that, even emptiness itself is empty, since it is interdependent on other things for one to claim that everything is empty, and thus, it must be empty (Priest and Garfield, 2003). Now if everything is *empty,* even itself, then to Nagarjuna, that would imply that both conventional and ultimate reality is in fact also empty. They both co-arise with one another and exist because of the other. In Nagarjuna's words from the MMK, "Something that is not dependently arisen [,] Such a thing does not exist. Therefore a nonempty thing does not exist (MMK XXIV: 19)."

This implication is profound, not only in Nagarjuna’s work or in Buddhism but profound in our understanding of our reality. Nagarjuna has pushed the limits of thought and provided a contradiction that raises many consequences and questions, as the dialetheic nature of his argument is strong. His contradiction is able to see the limits of language in our description of the unthinkable, as things beyond the limits of thought are not describable with one’s current language, this is the cause of contradiction in a non-contradictory viewpoint, In the MMK, Nagarjuna employs this strategy against non-contradictory arguments presented in front of him, demonstrating the emptiness and lack of essence in what others perceived to be the ultimate truth, by Nagarjuna’s standards (Garfield and Priest, 2003).

(2.1.3) One Nature = No Nature:

Through contradiction, Nagarjuna has proven that all things are empty, and if all is empty, it lacks an ultimate nature or essence. Nature is then by this definition, an empty set of empty things. But this itself is an empty thing, and to be "ultimately empty is, ultimately, to lack emptiness. In other words, emptiness is the nature of all things; by virtue of this they have no nature, not even emptiness (Priest and Garfield, 2003)." Nagarjuna's assertion of the contradiction is representative of the limits of language and thought. Nagarjuna claims that ultimate truth and reality are empty, if he claims as such, then he is telling an ultimate truth or *nature.* By doing so, he is contradicting the notion of empty nature, that there is no nature.

Nagarjuna has just then, as Garfield and Priest describe it, given a "fundamentally ontological conclusion" that states that it is in fact impossible to have a "fundamental ontology" (Garfield and Priest, 2003). This is itself a contradiction, an ontological contradiction, where the linguistics of humans reach their limits. Yet, Nagarjuna can still posit such contradiction and in doing so, he is able to say that emptiness is a necessary faculty of everything. Things are empty because they are so, that is things are empty because they are a *thing, "*To be is to be empty," it is a characteristic of its existence (Garfield and Priest, 2003)."

The ontological contradiction articulated is rooted in language, it is paradoxical due to the language available to us, to describe and express thoughts beyond the surface level of being. Nagarjuna has usefully shown that dialetheism is possible and there can in fact be contradictions at the limit of thought, because of the semantics and language limitations that exist to express such contradictions. Nagarjuna has expressed the inexpressible through his embracement of contradictions, giving insight into the issues surrounding ontology and language.

This is Nagarjuna's contribution to humankind, he has pushed beyond what is imaginable long before Western Philosophers even dabbled in the idea and has shown that by tolerating and giving credit to unorthodoxy schemas, one can achieve progress where progress could not be made.

(2.2) The Net of Indra:

In Huayan Mahayana Buddhism, the concept of interdependence and connectedness is prevalent and foundational. This comes from the dominant metaphor described in Huayan Buddhist philosophy described in Gram Priest's commentary in the *Moon Points Back,*

> "Far away in the heavenly abode of the great god Indra, there is a wonderful net which has been hung by some cunning artificer in such a manner that it stretches out indefinitely in all directions. In accordance with the extravagant tastes of deities, the artificer has hung a single glittering jewel at the net's every node, and since the net itself is infinite in all dimensions, the jewels are infinite in number. There hang the jewels, glittering like stars of the first magnitude, a wonderful sight to behold. If we now arbitrarily select one of the jewels for inspection and look closely at it, we will discover that in its polished surface there are reflected all the other jewels in the net, infinite in number. Not only that, but each of the jewels reflected in this one jewel is also reflecting all the other jewels, so that the process of reflection is infinite (Priest, 2015)."

After reading Nagarjuna's philosophy. this metaphor makes a lot more sense. It is clear interdependence is present in this metaphor. With each jewel standing for a node of reality, stretched out across space and time. I will further describe the philosophical underpinnings of the metaphor and its claim by analyzing Graham Priest's mathematical argument for the ontological importance of the Net of Indra.

(2.2.1) Interdependent Identity:

The notion of emptiness is crucial in the framing of this Net. The notion of identity itself is rooted in the relation of objects/things, and thus, this relational relationship decides the quality/characteristic of the object in observation. In other words, the relational relationship tells something about a, in relation to b. Graham Priest, points to Fezang (643-712 CE), the third Patriarch of Huayan's interpretation of identity, where he takes the identity of things, to be a substitution of identicals (Priest, 2015). That is, there is x and y, if x and y are identical, then anything true of y is true of x, and vice versa (Priest, 2015). Fezang believes that there is interpenetration, between all things, yet the relation described previously, does not allow for the interpenetration between objects, as Priest states, "The interpretations quickly collapse into what amounts, effectively, to trivialism: nearly everything is true (Priest, 2015)." This would signify that there is no difference between a car and a person, a dog, or a bird, etc., It does not seem to be the case that this is what the Net of Indra is trying to convey; the substitution of indeticals, does not warren the independent identity of everything, it is more nuanced than stating everything is identical. Rather, there is something common in nature in everything, that does in fact interpenetrate all (Priest, 2015). Francis H. Cook, states:

"First, we must accept the basic concept of emptiness itself. Second, we must consider emptiness to be so fundamental to the being of things that despite their obvious and real differences, they are alike in a more essential way in being empty. If we can accept these premises, then the claim that all things are identical does not seem quite so improbable, because identity is claimed on the basis of this common emptiness (Cook, 1977)."

Nagarjuna's argument for emptiness is clear, as the common nature of all is the emptiness of all. There is no quality or characteristic independent of everything else, this implies its emptiness, for the reason, one can say something about a, is because a can only be what it is in its relation to b. The interdepend existence of a and b allows an individual to claim something about the identity of a because of its comparison in relation to anything around it (Priest, 2015). Priest describes it as, "its locus (location) in a certain network of relations", the relations dictate what can be said about a and b. In similar regard, Hegel, in the *Phenomenology of Spirit*, states that in the early developmental stages of human consciousness, humans were able to state qualities, characteristics, and identity from the relation of objects and their comparison. For example, an individual has only ever seen and eaten one fruit in their life, which is an apple. They happen to them come across an orange tree. The individual has no prior knowledge of what an orange is or that there even existed other fruits other than apples. The human consciousness would try to say something about the orange in relation to the information the individual knows and what's in relation to the orange. The individual knows that apples grow on trees and as it seems so did this strange object, it is a similar shape, yet the texture is different and so is its color. From this process of relational analysis, the individual can claim qualities of the orange in relation to the apple and can claim something true of the orange because of its relation to an apple without any prior knowledge of the orange.

There is no intrinsic quality independent of the object, in the example, there is no quality in the orange or the apple that is ultimately independent of one another. The apple and orange are in themselves empty in that regard, yet this is the intrinsic quality that pervades all, so much so that an individual's observations of the apple can say something about the orange in its relation to other objects/things. Dialethism is once again, presents itself, where a contradiction is clear. Yet, the contradiction seems to say seething very familiar and intuitive about the way humans perceive the world and how knowledge is formed. This is the interdependent identity, which the relational network is based upon.

(2.2.2) The Network:

With the notion of interdependent identity, the Net of Indra starts to construct itself. The network would be comprised of a locus, to keep linearity, the locus in this network will be the apple and three objects that are in relation to the apple (a,b,c), mainly an orange, a grape, and a pear (Figure 1.1):

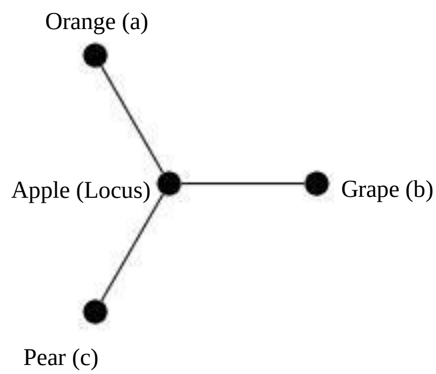
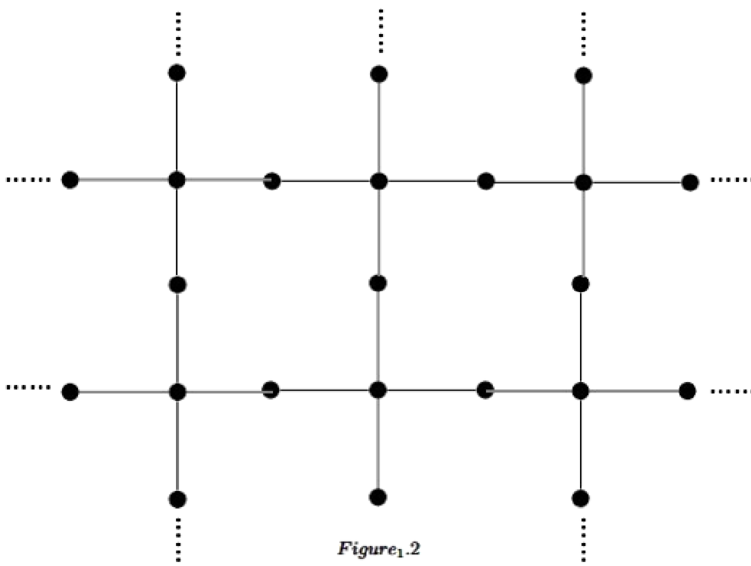


Figure1.1

The branches radiating from the center locus, are the relations from the locus point. Here the apple is the locus point, with the relational objects being other fruits. The branches are one-directional, yet as Priest states, the arrows (relations) are converse in nature, thus the branch emanating to *a*, the orange can in the same way be directed towards the apple (Priest, 2015).

Here, the apple (locus) → orange (*a*); if this describes a relation, then by converse properties, orange (*a*) → apple (locus) (Priest, 2015). This property can be applied to all the nodes in the net, as one can remove the context of the fruit and leave the nodes to be filled out by an individual. Thus, *a*, *b,* or *c* can be themselves locus from which relations branch out. This would leave the net to become an empty set of loci in relation to other loci (Priest, 2015).

With the context of the example removed, it starts to become progressive and indefinite when one starts to look at the relations from one locus to the other loci, each with its own relational net, that inadvertently is connected in some way to everything else. This is in fact a net of relations, where each locus is so, due to the interdependence and its permeability to other loci. In a re-interpretation of Priest diagrams on the Net of Indra, an expanded and full network can be represented as follows (Figure 1.2):



Figure$_1$.2

The relational network is thus, formed of an infinite number of reflationary nodes that radiate in all directions. This is the ontological structure of an object in question and is visually representative of the interdependence and permeability of the relations within everything as shown in the diagram. Priest states, “The ontological structure of each contains (encodes) the ontological structure of the other. The relation of two trees each being a subtree of the other is obviously a symmetric and transitive relation (Priest, 2015).”

(2.2.3) The Concepts of Li and Shi & Shi and Shi:

Tying the metaphor together once again, is the ultimate truth from Mahayana Buddhism: everything is empty, in other words ultimate reality is empty. The notion of ultimate reality and conventional reality is prominent in the Mahayana way of thought, as previously described in chapter 2, the two realities are interdependent of one another. The conventional reality is the observable, the empirical, the common experience of life. Whilst, the ultimate is beyond that conventional reality, it pervades conventional reality. Ultimate reality, as Priest puts it, "is the reality that appears once one strips away the reification of conventional thought: emptiness itself (Priest, 2015)."

Now if the ultimate truth is that everything is empty, then it must be so that ultimate reality, is also part of the same network. Just as conventional reality is empty and has a relational nature, then it must be so that if ultimate reality itself is empty, then it too must rely on a relational nature. Ultimate reality is in relation to conventional reality, just as conventional reality is in relation to the ultimate reality (Priest, 2015). The ontological structure of this network deems the *conventional phenomena* to be dependent on the emptiness of ultimate reality, where the characteristics and qualities observed form the conventional object are because of its relation to everything else. The existence of conventional reality cannot be so that it is independent of everything else, as this would not be descriptive of one's reality. By converse, it is only possible for ultimate reality to exist, because it "manifest itself through these phenomena (Priest, 2015)."

By this logic, the conventional and ultimate reality are interdependent on one another and are themselves empty, hence the ultimate truth is active and prominent. In this relational structure, the realities "interpenetrate" one another just as Fezang argued for in his interpretation of identity. The relational nature considers an individual the ability to say something about one's ultimate reality from its relation to the conventional and one can say things about conventional phenomena because of the interpenetration into the ultimate reality (Priest, 2015). In Huayan Buddhism, ultimate reality is referred to as *li* and conventional phenomena as *shi* (Priest, 2015). There are four categories that make up the *dharmadhatu*, or absolute reality.

1. *Shi*: The existence of phenomenal reality
2. *Li*: The existence of ultimate reality
3. *Lishi Wuai*: The interpenetration of *li* and *shi*
4. *Shishi Wuai*: The interpenetration of *shi* and *shi*

(Priest, 2015).

With the interpenetration of li and shi, it comes that conventional phenomena are transient with the ultimate reality, and if the ultimate reality is transient with the conventional then it can be so that, the relational network stemming from a locus (ultimate reality) is conversed and can be so that conventional reality can be treated as a locus, where ultimate reality stems from it. In this transient relational network, it can be so that in relation to the ultimate reality, the conventional phenomena interpenetrate other conventional phenomena in its relation to ultimate reality, of which it is pervasive in all conventional phenomena (Priest, 2015). Hence, the interpenetration of *shi* and *shi*, constituting the absolute reality, or the *dharmadhatu*,

This is how the Net of Indra is constructed, built from the relational nature of conventional phenomena and the ultimate realty, where the ultimate and conventional are transient with one another and interpenetrate indefinitely to build the absolute reality one finds themselves in. In the same manner as Priest, I will conclude the analysis on the Net of Indra with

Fezang's *Treaties of the Golden Lion*, which perfectly encapsulates the concepts behind the Net of Indra:

"In each of the lion's eyes, ears, limbs, joints, and in each and every hair, there is the golden lion. All the lions embraced by all the single hairs simultaneously and instantaneously enter into a single hair. Thus in each and every hair is an infinite number of lions, and in addition all the single hairs, together with the infinite number of lions, in turn enter into a single hair. In this way, the geometric progression is infinite, like the jewels of Celestial Lord Indra's Net."

(Fezang, Priest, 2015)

Ch. 3: Mahayana Buddhism Applied:

3.2 Nagarjuna and the Observer Problem:

(3.2.1) Emptiness:

The ontological structure defined by Nagarjuna is a powerful and unverifiable ontology that could aid in the interpretation of the Observer Problem. In the analysis of the concept of emptiness and the interdependent nature of reality; it is evident that the key difference in the past interpretations of the problem falls onto the isolation of a quantum system, leaving out the observer and any other relational factors in the act of observing and taking a measurement of the quantum state of the system.

Looking at the observer problem, specifically the argument formulated by Myrvold, in premises 4 and 5, the actual measurement observed is due to the quantum entanglement of the quantum system and the observer, as stated in premise 3. The Schrodinger wave equation would yield non-corresponding eigenvalues of the system in experimental settings, as the wave equation is not actually considering the observer's relational effect on the resulted observed measurement of the system. This is an observer-independent interpretation of the description of the quantum system, yet it runs into issues with non-zero valued variables in an experimental setting, that it fails to describe what is observed.

Applying Nagarjuna's ontological structure, the concept of emptiness is ever more important in solving this problem. The emptiness of everything implies, that there is no intrinsically independent quality or characteristic of the quantum system. That is, the quantum system is not independent of everything else, rather if empty, it is interdependent on its relations to have a quality or characteristics extracted from it. If the quantum system is not independent, then it must consider the relations in its network. In the observe problem, the relational objects, are the observer and any other observer in relation to the quantum system. It is not reflective of the reality exhibited by the experimental measurements conducted to leave out the effect the observation has on the quantum system, as by not including the observer, it is denying that there is some relation between the observer and the quantum system, when if fact that is least from true, as the wave function collapses due to the act of observation by an observer.

If the relation between the observer and the system is ignored, then it leads to the issues expected from the measurement problem because the obverses effect is not considered when trying to say something about the quantum system. This will thus, cause a faulty description of reality, which is not generalizable, and is not a complete description of reality.

The interdependent nature of everything, due to its emptiness, deems the observer to be part of the description of the system, as it interpenetrates the observer and the system. By the ultimate reality, the conventional is empty, just as the ultimate is empty. The emptiness warrants an interdependent existence, hence, the system itself is empty only because of its relational network. One cannot say anything about a system if there is nothing in the bet to draw relational conclusions from, as it just wound not exist if it’s not present in the relational reality of the world.

By using the dialethic approach and applying the concept of emptiness, it can allow physics to move one step forward in the right direction by dealing with the observer and its effects on the quantum systems observed.

(3.2.3) Inclosures:

Like state previously, the inclusion of the observer allows for a more complete description of the quantum state and system, when it considers the observer into the system. A mathematical representation of Nagarjuna's ontology, derived by Priest and Garfield. This mathematical argument encapsulates the how the observer dependent quantum system may look when applied. The representation is named an *Inclosure*, where properties (φ and Ψ) and a function (δ) satisdy the following conditions (Garfield and Priest, 2003):

1. $\Omega = \left(x{:}\,\varphi(x)\right)$ exist, and $\Psi(\Omega)$.
2. $For\ all\ x = \Omega\ such\ that\ \psi(x)$:
    a. $\neg\delta(x)\varepsilon x$ (Transcendece)
    b. $\delta(x)\varepsilon\Omega$ (Closure)

When δ is applied to Ω the result is, $\delta(\Omega)\varepsilon\Omega$ and $\neg\delta(\Omega)\varepsilon\Omega$ (Garfield and Priest, 2003). The Ω, is the set of all things that are empty and x is the set of things with a common nature, such that $x \subseteq \Omega$ and $\psi(x)$, since the common nature is a property of the things that are empty (Priest and Garfield, 2003). The nature of these things is represented by $\delta(x)$, that is the function of the common nature between the empty objects. If the common nature of the empty objects is the emptiness of the objects, then you get $\delta(x)\varepsilon\Omega$, which is the statement that all things are empty and the $\neg\delta(x)\varepsilon x$ demonstrates that the common nature of all the objects that are empty, is that they are empty (Priest and Garfield, 2003).

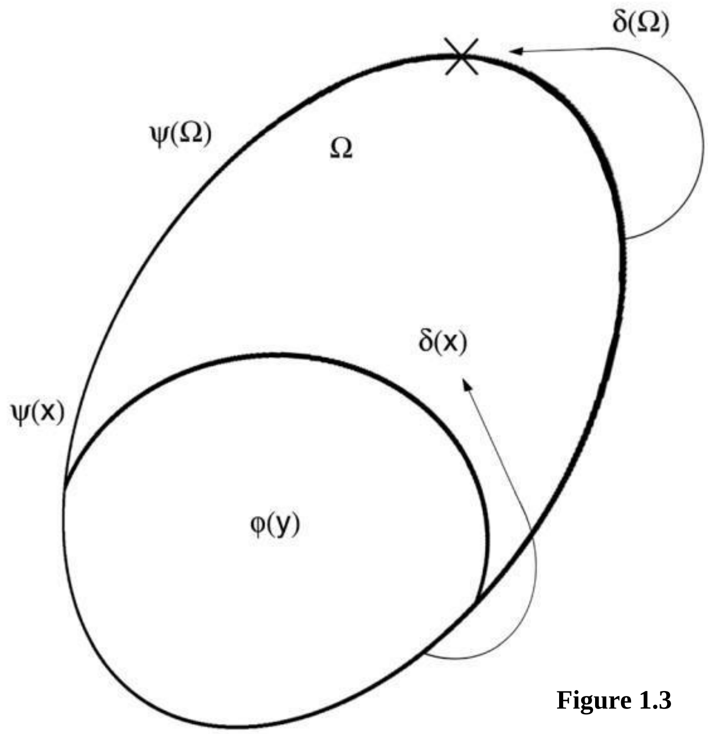


Figure 1.3

Inclosure Schema (Priest and Garfield 2003, pg. 16).

The inclosure schema provides, Nagarjuna's contradictions in a mathematical representation that can be applied to the observer problem. The Emptiness of all things with a common nature, allows the interdependence of these things with one another, where the emptiness determines the relational characteristics of the object that is being observed. In this case the observer is part of this enclosure schema, due to the relation of the observer with the quantum system. They are both in themselves empty, and only have meaning when they are in relation to one another; not independent of each other. Hence, the argument proposed demonstrates the progress that can be taken from adopting unorthodox ontological schemas like Nagarjuna's to further the study of quantum mechanics.

3.3 The Net of Indra on Quantum Entanglement:

(3.3.1) Interdependence and Relational Nature:

The Net of Indra demonstrates the interdependence that comes from the ultimate truth, that everything is empty, even the ultimate reality. The emptiness of conventional reality is transient with ultimate reality, it cannot be what it is without the other. This interpenetration of the relation between the ultimate reality and conventional reality weaves an infinite net of relations that give the conventional phenomena meaning. In such a network, the observation of a locus will tell an individual something about the nodes in relation to it, without having to observe the nodes themselves. The information of a conventional phenomenal object has transient and relational information encoded within the nodes and locus from the interdependent existence and relational nature of conventional and ultimate reality.

The ontological framework of this network serves as a precursor to the quantum entanglement phenomena. When looking at quantum particles, like electrons, the conventional phenomenal object is the electrons themselves. The information extracted from the observation of electron *a*, such as spin along an axis, has a relational nature that interpenetrates other conventional phenomenal objects, such as electron *b*. The concept of *shishi wuai*, determines the information measured from the electrons, as in a system the electrons are interdependent on one another and exhibit transient relational information (Priest, 2015). The electrons themselves are not independent of everything else, hence one cannot make a measurement of electron *a*, without including the relation to electron *b*, as the independent treatment of the electrons would not give a complete description of the system the electrons are part of, that is the relational network. If the spin of an electron is measured along an axis, the resulting measurement of the spin of electron b, will be non-local, that is, not independent from the measurement of electron *a*.

The relational relationship established between the electrons entangles the information of each particle with one another, thus, the measurement of electron a will affect the measurement of electron b. The affect is due to the relational nature of conventional phenomenal objects, as Shown in figure 1.3, emptiness interpenetrates all, and the information extracted from the network is so because of its entanglement to the other conventional phenomena observed. The φ represents the entanglement between the electrons and λ_n represents the conventional phenomenal objects. If so, then $\Psi(\varphi, \lambda_n)$ says something about the electrons because of the entanglement and relational nature of its network.

Figure 1.3

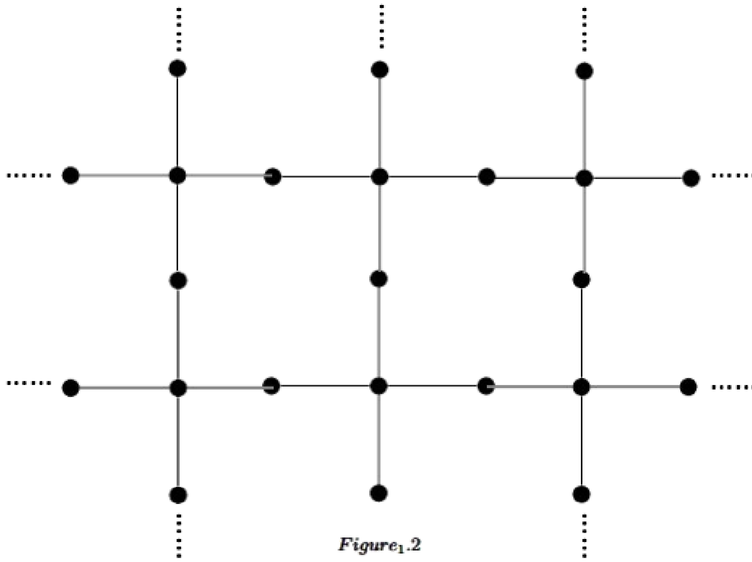
Measurement of electron a, λ_a, relates and affects the measurement of electron b, λ_b, due to the entanglement, φ. This property is transient between the electrons and can be done to electron *b* as with *a*. This is the phenomena of quantum entanglement laid out as an ontological framework that correctly defines these phenomena in quantum mechanics.

(3.3.2) The Quantum Net:

The Bell theorem describes the quantum entanglement phenomena seen in figure 1.3, as quantum mechanics and the nature of reality are relational, non-discrete, and non-local, as to explain why the measurement of one particle affects the measurement of the other, regardless of the distance between the local nodes of each respective particle, as the entanglement still holds, arbitrarily of the length of φ. Since the information for each is both in the node itself and in the entangled particle in relation (Myrvold, Wayne and Genovese, Marco and Shimony, Abner, 2019).

The Net of Indra is a stable foundation for the ontological framing of the relational nature of quantum particles and quantum mechanics, as it perfectly parallels contemporary science's definitions and descriptions of quantum entanglement, yet the framework was forged long before the concept of physics or quantum entanglement existed. The Net of Indra also plays into the observer problem, with Nagarjuna's argument bolstering the network establish, as the observe is also part of the relational network, since again the observer does influence the measurement observed, and thus, a description of the system would not be complete, since the system is being treated independently and locally to itself and not the observer.

The Net of Indra demonstrates the relational nature of all things, which be macroscopic or microscopic, since the relations between two elementary particles are just part of a larger and infinite net of relational interdependence that ultimately weaves the reality, one finds themselves in. (Figure 1.2) perfectly demonstrates the infinite net of reality that quantum entanglement entails.



Indra’s Relational Network (adapted from Priest, 2015)

Ch.4: A Push for Relational Quantum Mechanics

4.1 Relational Quantum Mechanics

(4.1.1) Grounded in Information:

Relational Quantum Mechanics is a novel interpretation formulated by Carlo Rovelli aiming at closing the interpretational gaps of quantum mechanics by addressing the observer problem and deriving formalisms based on the physical description of a quantum system (Rovelli, 1996). Rovelli employs an ontological schema that is relational in nature, where "Facts are realized in interactions between any two physical systems and are relative to these systems" and the "technical core is the realization that quantum transition amplitudes determine physical probabilities only when their arguments are facts relative to the same system (Rovelli, 1996)."

In other words, relational quantum mechanics takes an interdependent approach between the stemming relations from the system in question. The system is treated as an observer-dependent system compared to the observer-independent approach to quantum mechanics. Carlo Rovelli argues that the foundational approach that the physics was built upon, took a prima facie assumption that the wave function is independent of the observer, and this is what causes the issues in quantum mechanics like the observer problem (Rovelli, 1997).

The notion of the observer-independent system causes the experimental discrepancies observed by physicists, because of the *absolute* nature of the quantum mechanical formalisms. Rovelli argues that "the experimental evidence at the basis of quantum mechanics forces us to accept that distinct observers give different descriptions of the same events" thus, treating the systems as observer-dependent and employing a relational notion for the underpinnings of the formalism of quantum mechanics (Rovelli, 1997).

Relational Quantum Mechanics deems information at its core, as RQM targets the physical description of the empirical world physicist observe. The theory states that the transition amplitudes $W(a, b)$ determine the probability, $P(b, a) = [W(b, a)]^2$, that is a fact of the system (Rovelli, 2021). A fact is defined as a certain observable value at a specific time and place, Rovelli makes the point of distinguishing an RQM fact with classical QM by stating that:

1. Their dynamical evolution laws are genuinely probabilistic.
2. The spectrum of possible facts is limited by quantum discreteness.
3. Facts are sparse and relative.

(Rovelli, 2021)

The biggest distinction comes from three, as the facts are realized only in the relation and interaction of two physical systems, as the facts are relative to its interactions (Rovelli, 2021). That is for $W(a, b)$, it can only determine probabilities if and only if, the components of the system *a* and *b* are physically relational to each other in the same system (Rovelli, 2021). The informational belonging to the observer-dependent system described is contextualized as:

"[I]n the technical sense of information-theory, the amount of information is the number of the elements of a set of alternatives out of which a configuration is chosen. Information expresses the fact that a system is in a certain configuration, which is correlated to the configuration of another system (information source)."

(Rovelli, 1997)

The information is a relational based information theory, which constitutes the interactions between objects and systems. This approach, often championed by John Wheeler, considers the quantum mechanical nature of the study as an observer-dependent theory that is unverifiable, compared to the classical interpretations that aren’t experimentally based and don’t describe the physical world in relation to its interaction, mainly the observers (Rovelli, 1997).

(4.1.2) Postulates Reconstructed:

Rovelli furthers this approach by formulating two postulates from the relational nature previously described. The postulates are as follows; "Postulate 1: There is a maximum amount of relevant information that can be extracted from a system" and "Postulate 2: It is always possible to acquire new information about a system" (Rovelli 1996, pg.11-12). The postulates are derived from the previously mentioned notion of information in quantum systems, as the first postulate is a description of the "quantum discreteness" in QM (Rovelli, 1996). Rovelli states that discreetness is a "core" principle of quantum mechanics, as by the Planck constant, $h = 2\pi\hbar$.

The constant establishes a scale from which physicist may approximate the accuracy of the measurements made from classical mechanic's continuity (Rovelli, 1996). Described by Carlo Rovelli (1996), the volume *V(R)* of a phase space region R has dimensions $(Length)^2 \times \left(\frac{Mass}{Time}\right)$ per degree of freedom. The Planck constant fixes the size of the smallest regions a measurement can determine, mainly, $V(R) \geq 2\pi\hbar$, where the possible values that a variable distinguishing point may find itself within the region R of phase space, $N \leq \frac{V(R)}{2\pi\hbar}$. This give the variable a discrete measurement when it is separating finite regions of a phase space (Rovelli, 1996).

This attribute or principle of quantum mechanics deems postulate 1 to be exactly what was described that the information observed from the system is based on the discrete values of the variables in a phase space. Postulate 2 describes the probabilistic nature of quantum mechanics, away from a deterministic perspective, as Rovelli states, "there is no way of adding new information once the full information about a system is achieved" and a deterministic perspective does just that (Rovelli, 2021). The postulates collaborate with one another, as the discrete values measured in systems, is what the observe experimentally measures, whilst postulate 2 preserves the probabilistic nature of adding new information from the system in relation to the observer and its interactions. It allows for something new to be said about a system, even if one previously already described the system, as the interactions depend on relation, it would not affect the future measurement made (Rovelli, 2021). Relational interaction depends on the present relevant interactions in the systems.

The reconstruction of the two postulates, gives this interpretation weight, as it addresses the core formalism in quantum mechanics. This is enough to build the reinterpretation of quantum mechanics through the relational nature Rovelli expresses.

(4.1.3) The Observer and the Measurement:

With the framework of RQM laid out, Rovelli tackles the observer problem from the relational nature of information and of the observer-dependent systems. The observer problem is investigated in more depth in the first chapter; hence I will not be explaining it here. Yet, the main issue stems from the unitary evolution of the Schrodinger equation and the collapse of the wavefunction. The probabilities measured from the collapse of the wavefunction do not yield the same eigenvalues (measurements) or the unitary evolution equation. That is, the predicted wavefunction was not equal to the unitary evolution measured, and hence not a complete description of the system, hence, the measurement problem.

Classical mechanics would state that the collapsed wavefunction would be what is measured and observed, whilst the unitary evolution is the description of the system if an observer did not measure the systems. This approach to the answer does not provide useful information about the description of the world around us and negates the interaction of the observer and the system (Rovelli, 2021).

Relational Quantum Mechanics' solution to the observer problem comes from the facts labeled, as "facts are labeled by the systems involved in the interactions and the transitional amplitudes *W (b, a)* have physical meaning only if a and b are relative to the same system" (Rovelli, 2021). This is where relational interdependence is presented, the measurements are due to relational interactions of the components in the system with the observer. Without the inclusion of the observer, one could not describe the facts of the system they are in relation to, as they would only have a dilemma described by the classical approach to the observation problem. The labeling in relation to the system gives it the ability to extract fact based information from the interactions.

Conclusion: The Ontological Framework for Relational Quantum Mechanics:

Nagarjuna's argument for emptiness warrants more analysis and application, as the ontological structure proposed by Nagarjuna, is one that is applicable to one of the most rigorous and perplexing studies in science. Yet, his argument pre-dates the establishment of the quantum phenomena and the interpretation of a relational interpretation of quantum mechanics. The interdependence of all things pervades deeply, even into the quantum level, as previously described, the ontological schema is applicable to the observation problem and parallels the same ontological framework that Rovelli provides for his novel interpretation. This is more than a coincidence, but a well-formulated argument and schema that does in fact describe the conventional reality human find themselves in, where it can be unverifiable and quantified by the relation interpretation of quantum mechanics provided.

In a similar fashion, the Net of Indra is derived from the same line of ontological thought, where there exists an interdependent and relational nature of conventional reality that allows humans to say something about a quantum system because the observer itself is part of the system. This solves the observer problem and directly describes the quantum entanglement of particles. The network, as previously shown does provide the same description of the phenomena as Schrodinger and Einstein discussed. The framework itself has gone from the ontological description of the world before systems of science solidified itself as the describer of the world, to now in modern times the framework still holds with novel interpretations.

Considerations and Further Discussion:

This serves as an example of the interdisciplinary application of frameworks and schemas, which could potentially provide more progress and answers to the very issues plaguing different fields of study. The Mahayana Buddhist philosophy compliments and harmonizes with quantum mechanics, and the result is the interpretation provided by Carlo Rovelli.

The dialethism found in philosophy pushes the limits of thought to a boundary not often crossed by Western science and philosophy, hence the orthodoxy nature of the principle of non-contradiction. By stepping away from such an assumption of the world, Rovelli can give a complete description of the quantum system due to the relational and interpenetrating nature of all things, mainly because they are empty, and information about the world arises from its interaction and relation in the network. Mahayana Buddhist philosophy can help clarify issues in physics by providing a diversified perspective, from which new doors can open leading to a more complete univariable description of the world.

Hence, this paper argues for the implementation of varying ontological and epistemic schemas that help interpret issues plaguing science, specifically quantum mechanics, and provide an interdisciplinary analysis that yields promising results, beyond the Western orthodoxy sphere. Mahayana philosophy demonstrates the relational nature of the world, the macro if one will, and even at the microscopic, and sub-atomic, the philosophy holds true.

There must be more interdisciplinary analysis across fields like philosophy and physics to adopt a more interdependent perspective. Most studies aim to best or fully understand whatever they are studying, hence it would not do a lot if every study was taken as independent of everything else, as that is simply not true of the world humans inhabit. In some way or another, there is a relation, no matter how weak it may be, it is still part of the network. Thus, it is crucial to try to have a diverse perspective if the information produced is meant to describe the world and be universalizable. With new literature produced each year, this field of interest and study is being to grow and garner the academic merit it has proven itself to already have.

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