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Quantum Theory of Consciousness

Gangsha Zhi[1], Rulin Xiu[1,2]

[1]Tao Academy, Richmond Hill, Canada
[2]Hawaii Theoretical Physics Research Center, Keaau, HI, USA
Email: rulingxiu@gmail.com

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Abstract

Both consciousness and quantum phenomenon are subjective and indeterministic. In this paper, we propose consciousness is a quantum phenomenon. A quantum theory of consciousness (QTOC) is presented based on a new interpretation of quantum physics. We show that this QTOC can address the mind and body problem, the hard problem of consciousness. It also provides a physics foundation and mathematical formulation to study consciousness and neural network. We demonstrate how to apply it to develop and extend various models of consciousness. We show the predictions from this theory about the existence of a universal quantum vibrational field and the large-scale, nearly instantaneous synchrony of brainwaves among different parts of brain, body, people, and objects. The correlation between Schumann Resonances and some brainwaves is explained. Recent progress in quantum information theory, especially regarding quantum entanglement and quantum error correction code, is applied to study memory and shed new light in neuroscience.

Keywords

Quantum Theory of Consciousness, Hard Problem of Consciousness, Measurement Problem of Quantum Physics, Schumann Resonances and Brainwaves, Quantum Information Theory, Quantum Entanglement, Large Scale Synchrony of Brainwaves

1. Introduction

Consciousness relates to awareness. It is subjective, nonpredictable, nondeterministic phenomenal experience of internal and external worlds. Consciousness is associated with a sense of self, feelings, choice, free will, control of voluntary behavior, memory, thought, language, and imagination [1] [2].

What consciousness really is and how it comes about remaining a mystery. According to David Chalmers, the hard problem of consciousness explains why

and how a physical objective process generates a specific subjective experience [3] [4]. The easy problem addresses the various mechanisms that the brain uses to integrate information, categorize and discriminate environmental stimuli and memories, focus attention, and perform other tasks associated with conscious experience [5] [6]. Currently, although much progress has been made, neuroscience continues to have difficulty in addressing the hard problem of consciousness.

Most research in neuroscience is based on classical physics. In this paper, we propose that consciousness is a quantum phenomenon. Based on a new interpretation of quantum physics, we propose a quantum theory of consciousness (QTOC). We show that this quantum theory of consciousness can address both the hard and easy problem of consciousness and other challenging and unsolved problem in the science consciousness and neuroscience.

Physics studies what everything is made of and how it works. Physics uses mathematical formulas to describe experimental data and make predictions, which can lead to new discoveries and technologies. Physics is the foundation of the natural sciences. Quantum physics is the most fundamental physics theory so far [7]-[12]. It studies what everything is made of and how it works at the deepest level right now. Quantum physics makes the most precise predictions and has enabled breakthrough progress in science and technology. For instance, development in quantum physics has led to the discovery of the structure of DNA, which reveals how life is reproduced [13].

Quantum phenomena are the elementary, basic, and fundamental phenomena underlying all observed phenomena. For instance, quantum phenomena are what make the sun shine [14], due to the quantum effect, uncertainty of location and momentum, wavefunction overlap, and quantum tunneling. Classical physics—such as Newtonian mechanics and electromagnetics—is shown to be the accumulative average of quantum phenomena and derivable from quantum physics [11].

1.1. Four Reasons That Consciousness Should Be Studied with Quantum Physics

Due to the current prevalent misunderstanding about quantum physics and tendency of ignoring it among researchers in neuroscience and biology, here we want to list four major reasons about the importance to apply quantum physics in the research and studies of consciousness and life science in general.

Both quantum phenomena and consciousness are subjective and non-deterministic [7]. Indeed, it should not be considered coincidence that two of the most fundamental aspects of existence—*i.e.*, consciousness and quantum phenomena—share the same subjective and probabilistic nature. Classical physics does not have such nature. This is the first reason to use quantum physics to study consciousness.

Quantum physics uses wave function to studies the physical, energetic, and

informative aspects of an object. The informative aspect of an object—*i.e.*, the information contained inside an object—is closely related to its consciousness. Classical physics averages out the different possibilities represented by the information [11]. As a result, it cannot address the informative/conscious nature of our existence. This is the second reason why quantum physics is needed to study consciousness.

Thermodynamics and statistical physics study the relation between entropy, energy, pressure, and other physical aspects of an object. Entropy measures disorder, which is associated with the informative aspect of an object, as shown by Claude Shannon's information theory [15]. Max Tegmark [16] estimates decoherence time scales for ions involved in the propagation of action potentials to be 10 to 20 orders of magnitude smaller than the relevant time scales of neural dynamics. He argues that the degrees of freedom of the human brain that relate to cognitive processes should be thought of as a classical rather than a quantum system—*i.e.*, that there is nothing fundamentally wrong with the current classical approach to neural network simulations.

We disagree with Tegmark's proposal because it ignores the order, correlation, and coherence that exist and in fact dominate in the brain and life in general. We propose and will show that—although decoherence as indicated by Tegmark exists in the brain and everything observed in nature—what leads to consciousness and life in general is the stable structure, order, connection, correlation, and coherence [17] [18]. The connection, correlation, and coherence that underlie conscious experience are due to the established stable atomic, molecular, cellular, and other internal structures within the brain and the whole body. These structures are obviously much stronger than the decoherence effects calculated by Tegmark; otherwise, there would be no stable atoms, molecules, cells, brains, bodies, or life.

To study the consequence of structure, order, connection, and coherence, quantum physics is needed. For instance, to study the simplest atomic structure—the hydrogen atom—Niels Bohr realized that it was necessary to use a new physics based on a set of new rules, *i.e.* quantum physics. He helped found and develop quantum physics, which led to the prediction of the relationship between the hydrogen atom's structure and spectrum [7]. The spectrum of a hydrogen atom consists of the vibrations that the hydrogen atom can resonate with and emit. Life and consciousness are based on structure, order, connection, correlation, and coherence. Neural systems, membranes, microtubules, DNA, and the structures of living systems have greater similarity with crystals, semiconductor materials, superconductors, lasers, and superfluids. In classical mechanics, the existence of such phenomena is impossible; they need to be studied with quantum physics. This is the third reason that quantum physics must be involved in the study of consciousness.

Quantum physics reveals that everything has both particle and wave nature [7] [8] [9]. Quantum physics studies the relation between the wave and particle

nature of an object. For instance, quantum physics is needed to understand even some of the simplest vibrational fields, such as black-body radiation and the radiation spectrum of the hydrogen atom. Copious brainwaves are observed [19]. To study the relationship between brainwaves, brain structure and function, and the information carried, received, and processed by the brain, quantum physics is needed. This is the fourth reason that the study of consciousness must necessarily involve quantum physics.

1.2. Current Status on Using Quantum Physics to Study Consciousness

The hesitation in applying quantum physics to study consciousness or life is due to the lack of true understanding about the metaphysical meaning of quantum physics. Currently, most physicists use quantum physics as a mathematical tool to perform calculations related to the microscopic world, without fully apprehending the overarching significance and implication of quantum physics.

In quantum physics, everything is described by a wavefunction, which portrays the probabilities of an object existing in certain states. The observed quantum phenomena depend on the observer. The much-debated quantum measurement problem concerns how observed, subjective quantum phenomena arise from an objective and indeterministic quantum field described by the probabilistic wavefunction. Various interpretations of quantum physics are proposed to address these paradoxes, including the Copenhagen interpretation [8] [9], pilot-wave theories [20], and many-world interpretations [21] [22]. Wolfgang Pauli, John von Neumann, and Eugene Wigner, and more recently Henry Stapp and philosopher David Chalmers, have expressed the view that conscious observation *causes* quantum state reduction—*i.e.*, consciousness "collapses the wavefunction" [23] [24] [25]. However, this dualistic view leaves both consciousness and quantum superposition scientifically unexplained.

The application of quantum physics in neuroscience has been explored in a number of books and papers [26]-[35]. A prominent theory among these published works has been developed by Roger Penrose and Stuart Hameroff, who propose self-collapse or "objective reduction" ("OR") of quantum superposition states—a "collapse of the quantum wavefunction"—as the possible non-computable source for consciousness [36] [37] [38]. Penrose [26] [27] contends that collapse occurs naturally due to an objective threshold in the fine-scale structure of the universe, such that events *produce* the rudiments of phenomenal conscious experience. Yet quantum state reduction is yet another mystery. In the 1960s, Luigi M. Ricciardi and Hiroomi Umezawa [33] suggested using the formalism of quantum field theory to describe brain states, with particular emphasis on memory. This proposal has been further refined [39] [40] [41] and developed by including effects of dissipation, chaos, fractals, and quantum noise [42] [43] [44] [45] [46]. Walter Jackson Freeman and Giuseppe Vitiello envision a way in which mental activity can be explicitly explained in the context of quantum field theory [47] [48] [49] [50].

In our previous work [51] [52] [53], we suggest a new interpretation of quantum physics, which can help explain the subjectivity and uncertainty inherent to quantum physics. In this paper, we build a quantum theory of consciousness (QTOC) based on this work. In the following, we will first reveal the principles of QTOC, then we will explore how QTOC can address the hard problem of consciousness, its application and predictions.

2. Principles of Quantum Theory of Consciousness (QTOC)

We propose a quantum theory of consciousness (QTOC) based on two principles derived from our new interpretation of quantum physics [51] [52] [53].

Principle One

The basic constituent of everything is the quantum vibrational field, which carries matter, energy, and information.

This principle derived from quantum physics suggests that everything is a vibrational field [7] [8] [9] [10] [11]. Vibration—also called "wave"—is periodic oscillation extending over space and time, characterized by wavelength, frequency, and amplitude. Quantum vibration also behaves like a particle in some ways, having specific mass, charge, spin, energy, and momentum. The exchange of energy, momentum, spin, charge, and mass can only take place wholly in quanta instead of partially. The quantum vibrational field is mathematically described by a wavefunction, which shows the types and quantities of waves existing in the field. Quantum physics has developed various techniques to calculate wavefunction, such as the Schrödinger equation, Feynman path integral, and matrix method. In the Feynman path integral formulation of quantum physics, the wavefunction is obtained by summing over possible trajectories [11].

In our previous work, we propose that the quantum vibrational field of an object has three basic aspects: a physical aspect, an energetic aspect, and an informational aspect [51] [52]:

1) The physical element—which we will call "matter"—is what we see, hear, touch, observe, measure, and experience. It is the physical existence. It consists of what one can observe and measure, such as frequency, mass, spin, charge, relationship, finance, career, body, electrons, gravity, electromagnetic field, etc.

2) The energetic aspect—which we simply call "energy"—is what moves and changes matter, such as energy and momentum.

3) The informational aspect—which we simply call "information"—is what informs; it is what gives form and shape to the matter and energy. It relates to entropy, the possible states, and the probability to be in a particular state. Information can be expressed as answers to questions. Since all answers to questions can be framed to be "yes" or "no," the mathematical measure and expression of information—known as "bit"—consists of two numbers, such as (0, 1).

This proposal of everything being a quantum field carrying matter, energy, and information is related to ancient Chinese wisdom known in traditional Chinese medicine and Tao wisdom as Jing Qi Shen, also referred as San Bao

which means three treasures or three jewels [54]. It is also a natural deduction from quantum physics. In quantum physics, wavefunction describes the vibrations and the vibrational field associated with an object [7] [8] [9] [10] [11]. From the wavefunction, one can calculate the matter, energy, and information of an object carried in the quantum vibrational field.

According to the information theory founded by Claude Shannon [15], information describes the possible states within an object. Information is intrinsically probabilistic. The probabilities of wave function describe the information in an object. The nondeterministic nature of quantum physics is due to the fact that quantum physics includes and can describe the information aspect of an object, while classical physics, except for thermodynamics, cannot describe the information aspect; the latter instead provides an average of different possibilities [11]. The insight that everything is made of information, energy, and matter can explain why quantum physics is fundamentally uncertain and nondeterministic. This insight is also the key for bringing consciousness into natural science and explaining the subjective and uncertain nature of consciousness. As explained further below, consciousness is closely related to the quantum field and information aspect of everything.

Principle Two

An object absorbs quantum vibrations through resonance. The reception and processing of vibrations—including information, energy, and matter—lead to subjective conscious experience.

The absorption of a quantum wave happens through resonance. The wavefunction reveals the possible energy states of an object and the probabilities to be in the states. The object can absorb or emit vibrations that have the energy equal to the energy difference between these possible states [7] [12]. This process is called "resonance." If one knows the wavefunction of an object, it is possible to calculate specifically what kinds of vibrations it can resonate with and thus receive or emit [53]. From this calculation, one can obtain the spectrum of an object.

Quantum phenomena occur through the measurement process, in which detectors are used to initiate, create, and exhibit quantum phenomena [51] [52] [53]. A detector is an instrument that can absorb vibrations and exhibit certain changes. For instance, a camera is a detector, which can absorb light and create a photo. A radio's antenna is a detector that receives radio waves so that the radio broadcast can happen. Our eyes, ears, nose, and skin are all detectors. Detectors receive the vibrations, information, energy, and matter related to a phenomenon or an object, consequently bringing in matter, energy, and information, which consequently induce certain observable or measurable changes or experiences. Detectors are what "collapse the wavefunction" through receiving vibrations, information, energy, and matter from what is being observed in QTOC. Quantum measurement occurs due to the detectors [51] [52] [53].

One can only observe the quantum vibrations and the associated phenomena when the detectors can resonate with the vibrations. For example, we can see

visible light because our body has developed a system to resonate with visible light, receive these vibrations, and process the information, energy, and matter carried by the visible light. Specifically, the photoreceptors in retina can absorb the visible light through resonance and then turn them into electrical signals, which travel to the brain. Then the brain turns the signals into the images we see. We can't see ultraviolet light because we don't have the detector, photoreceptors, to receive it.

An object or phenomenon can appear to be a classical object as a point rather than a vibrational field when the spatial and temporal scale of the vibrations associated with it are much smaller than the observation scale. For instance, a beam of visible light may appear as a particle, following a straight path, rather than a wave, because it vibrates at a frequency too fast and at a wavelength too small for its wave nature to be observed. Classical physics provides an appropriate description of quantum phenomena when the observation scale is much greater than the time scale of the quantum vibrations associated with the phenomena. For instance, electrons, visible light, and protons may appear as particles, when their quantum vibrational time scales (10^{-20} seconds for an electron, 10^{-15} seconds for visible light, 10^{-23} seconds for a proton) are much smaller than the observation scale. In this case, our observation of them is the average over their possible quantum states, the classical mechanism description is sufficient.

Similar to quantum phenomena, consciousness occurs when one applies one's internal detectors to receive the vibrations, information, energy, and matter related to an object or phenomenon. Each object has its unique detectors determined by the possible vibrations it can absorb or emit, its spectrum. One can calculate an object's detectors, *i.e.* its spectrum, using quantum physics. For instance, it is possible to calculate the hydrogen atom's wavefunction. The structure of a hydrogen atom determines the possible quantum energy states. When a vibration's energy is the same as the energy difference between the two possible states of a hydrogen atom, the vibration can be absorbed by a hydrogen atom. This process is called "resonance" in quantum physics. From the wavefunction, one can calculate all possible vibrations with which a hydrogen atom can resonate. It yields the atomic spectrum and detector of a hydrogen atom. When an atom has more structure than hydrogen, its spectrum includes more possible vibrations [55]. It can thus resonate with and absorb more vibrations. When atoms form molecules, when molecules form cells, when cells form organs, and when other internal structures form, the spectra and detectors expand to include a greater range of frequencies that can be absorbed and emitted. As each additional structure is formed, the spectrum and detectors of the original structure remain roughly the same, and new spectrum and detectors are added to form richer overall spectra and detectors.

Quantum vibrations extend over spacetime. They are the basic constituents of everything. They exist by themselves and are not carried by anything. For example, a photon is a quantum field. It is an elementary particle and wave. There are

also "classical" vibrations that are carried by matter. For example, sound is a classical vibration carried by air. An ocean wave is a classical vibration carried by water. The nature of classical vibrations depends on the specific matter through which they are traveling. From the wavefunction, one can calculate both the quantum and classical vibrations that an object can resonate with and receive.

A moment of conscious experience starts when one's detectors receive vibrations, information, energy, and matter related to a phenomenon or an object, thus inducing certain noticeable changes or experiences within. One's detectors determine what kind of conscious experiences one can have. The type of detector determines what can be observed and experienced. If one turns on different detectors, one's experience will be different. This is the basis of the subjective nature of consciousness. This is why the same thing can be experienced differently by different observers. One can also have different experience about the same thing if one applies different detectors. For example, with normal camera that can capture the visible light, we can obtain a photo showing the image of visible light. With a camera that can capture infrared light, we obtain a photo showing the image of infrared light. With our eyes, we see visible light images. With our ears, we hear sound. They are different phenomena and experience because we use different detectors.

In Figure 1, it shows that everything is a vibrational field, which is mathematically expressed by wave function:

$$\psi = \sum_{n=1}^{N} a_n e^{i(E_n t - p_n x)/\hbar}$$

The wave function informs the possible energetic states (E_n, p_n) and the probabilities a_n at these states, which relate to the energy and information of an object. The matter is what is being observed and experienced by the observer. It is determined by what detectors the observer applies and utilizes.

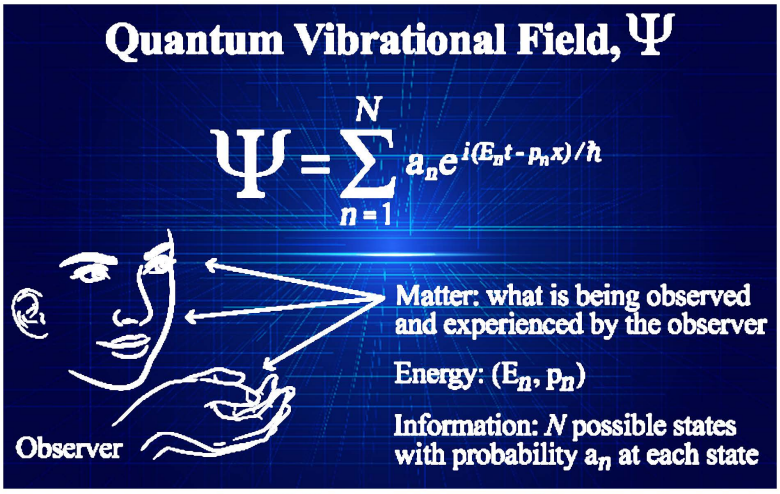

Figure 1. Mathematic description of quantum vibrational field and its relationship to conscious experience.

3. Address the Hard Problem of Consciousness

The hard problem of consciousness—also called the "mind/body problem"—is to understand how matter such as the human brain is capable of having subjective experience [3] [4] [56]. David Chalmers points out that the solution of hard problem of consciousness requires "psychophysical laws" governing the relationship between mind and matter. To solve the hard problem of consciousness, David Chalmers proposes three speculative principles [4]:

1) The principle of structural coherence

This is a principle of the isomorphism between the structures of consciousness and awareness.

In QTOC, consciousness depends on the detectors. Awareness is due to the activation and use of detectors. Both consciousness and awareness are due to the reception of detectors; thus, they are correlated.

2) The principle of organizational invariance

This principle states that any two systems with the same fine-grained functional organization will have qualitatively identical experiences.

In QTOC, one's vibrational field—which is mathematically described by the wavefunction—determines all of one's qualities and behaviors, including its detectors and processors of information, energy, and matter. If two systems have a similar wavefunction—*i.e.*, have the same fine-grained function organization—they will have qualitatively identical experiences.

3) The double-aspect theory of information

Information (or at least some information) has two basic aspects: a physical aspect and a phenomenal aspect.

In QTOC, information is carried by vibrational fields, which is the physical aspect of information. One can experience the information through one's detectors and processors of information. Therefore, information has both physical and experiential aspects.

One can thus conclude that the three principles suggested by David Chalmers can all be derived from QTOC. In this QTOC, mind is closely related to the information. In previous work [51] [52], we point out that information has three aspects:

1) Content of information

2) Receiver/detector of information

3) Processor of information

One can calculate one's receiver and processor of information from one's wave function. Conscious experience occurs through the following process:

1) Some information in the vibrational field or environment receivable to the observer shows up and draws the observer's attention

2) The observer or experiencer's receiver/detector receives the information.

3) The processor processes the received information and directs where energy goes.

4) Energy moves and changes the matter.

5) Matter is what one observes and experiences.

In QTOC, the mind and consciousness are related to the matter via the 5-step manifestation process mentioned above. The two principles specify the quantum mechanism about how the body can have conscious experience and how consciousness can change the body.

Through laying down how the subjective and indeterministic quantum phenomena occur through quantum measurement, QTOC can address the hard problem of consciousness.

4. Applications and Predictions of QTOC

4.1. Application in Developing Various Models of Consciousness

QTOC supports panpsychism [57]. It indicates that everything—including electrons, atoms, molecules, cells, organs, trees, rivers, mountains, Earth, moon, sun, stars, galaxies, and the universe as a whole—can each have consciousness to a certain extent because they all contain information, can receive and process information, and experience resultant change accordingly. One can use quantum physics to calculate the level, quality, and quantity of the consciousness of an object. To do so, one needs to calculate the object's wavefunction. From the wavefunction, one can derive the content, receiver, and processor of information, energy, and matter.

QTOC provides the physics foundation and mathematical formulation to study panpsychism and other theories and models of consciousness, such as integrated information theory [58], general resonance theory [59] [60], field models [61] [62] [63], global workspace theory of consciousness [64] [65], theory of consciousness as memory and attention [66] [67], and other models and theories of consciousness [5]. For instance, with QTOC, one can calculate the integrated information proposed in integrated information theory, the coherence and synchrony suggested in general resonance theory, the field indicated in field theory, the cognitive global workspace proposed in the cognitive global workspace theory, and the memory and attention indicated in the theory of consciousness as memory and attention.

Take the global workspace theory of consciousness as an example. The global workspace theory of consciousness proposes that there is a "global workspace" system underlying conscious experience. The global workspace is the publicity organ of the nerve system, and its content—which corresponds roughly to conscious experience—is distributed widely throughout the system. The brain is considered as a vast collection of specialized automatic processors, some nested and organized within other processors. Processors can compete or cooperate to gain access to the global workspace, enabling them to send global messages to any other system. Any conscious experience emerges from cooperation and competition between different input processors.

According to QTOC, everything is essentially a quantum vibrational field extending over space and time and carrying information, energy, and matter. Be-

cause of this, there exists a universal vibrational field which everything is part of and can access to [51]. This quantum vibrational field plays the role of the global workspace. The assumption of a global workspace and global messaging in global workspace theory can be a natural result of QTOC. However, there is a crucial difference between the universal vibrational field suggested by QTOC and that discussed in the global workspace theory of consciousness. The universal vibrational field suggested by QTOC is much larger than the localized global workspace in global workspace theory. It exists not only within the brain, but also encompasses the whole body and indeed the entire universe. It can be accessed by everything.

4.2. The Prediction of a Universal Vibrational Field and Synchrony

The nature of quantum vibrations is its possible existence in all space and time. Because of this, a natural prediction from QTOC is the existence of a universal vibrational field, of which everything is part, to which everything can access *i.e.* receive or send vibrations, information, energy, matter from or to it.

Different parts of the brain and body can receive vibrations from the universal vibrational field depending on the range of vibrations with which they are able to resonate. The types of vibrations that a particular part of the body can resonate with and absorb depend upon its atomic, molecular, cellular, neuronal, and other internal structures. If different parts of the body or brain resonate with and receive the same group of vibrations from the universal vibrational field, their states or vibrations can become synchronized or coherent with each other. This is similar to the process that if everyone tunes one's clock with a universal clock, everyone can become synchronized with each other quickly. This is also similar to the mechanism of how a laser is created. Laser is coherent light. It is created by the light emitted from a crystal bouncing back and forth between two mirrors to stimulate the generation of the coherent light.

There are experiments indicating the correlation between cognitive performance and heart rhythm [68]. Social and global coherence has been discovered, for instance, through heart rhythm synchronization between pairs of people and in groups, as well as with the resonant frequencies in Earth's magnetic field [69] [70]. It has been discovered that the heart rhythm of humanity can be synchronized interpersonally across the planet with the resonant frequency of the Earth's magnetic field. The impact of solar activity on Earth weather and human history, including mental life and activity, has been observed [71] [72] [73] [74] [75]. All of these findings suggest that the effect of the universal vibrational field extends far beyond the brain and body, encompassing the whole of humanity, Earth, and the solar system.

4.3. Schumann Resonance and Brainwaves

Schumann resonance (SR) is a set of frequencies generated by Earth-ionospheric

cavity resonance. The similarity between brainwaves such as alpha (8 - 12 Hz), beta (12 - 30 Hz), and gamma (30 - 100 Hz) with SRs and the tendency of electroencephalogram (EEG) rhythms to become synchronous with SR activity was first reported by Koenig [72]. Pobachenko *et al.* [73] found that variations in EEG were correlated with changes in the SR across the daily cycle. Persinger *et al.* have also studied EEG activity and SR, finding that the power within the EEG spectral profiles had repeated periods of coherence with the first three SR resonance frequencies (7 - 8 Hz, 13 - 14 Hz, and 19 - 20 Hz) in real time [74].

This repeated re-synchronization within the alpha, beta, and gamma ranges of brainwaves happens within very short time lags covering very long distances. The dominant mechanism within classical physics for neural interactions by axodendritic synaptic transmission or gap junction coupling cannot fully account for the precise coherence of global brainwave synchrony [75] [76]. Freeman and Vitiello apply many-body quantum field theory developed in condensed matter physics to describe these long-range coherent brainwaves [76]. Hunt and Schooler propose general resonance theory to explain how resonating structures communicate and achieve shared resonance [59]. However, the specific mechanism remains unknown in these theories.

According to QTOC, the similarity between SR and theta, alpha, beta, gamma, and other brainwaves is not a coincidence. Alpha, beta, gamma, and other brainwaves come from the ability of the brain to resonate with SR, which is part of the universal quantum vibrational field. These resonances bring the SR inside the brain. If different parts of the brain can resonate with SR, then they can receive and emit brainwaves in the range of SR. Through this process, they can establish coherence with SR. This can lead to synchrony among different parts of the brain. The SRs going back and forth inside our brain can stimulate different parts of the brain simultaneously. This is why instantaneous synchrony and coherence of different parts of the brain occurs in alpha (8 - 12 Hz), beta (12 - 30 Hz), gamma (30 - 100 Hz), and possibly other brainwave frequency bands. This type of coherence and synchronicity can also happen between different parts of the body, people, and different objects on Earth, as have been shown in experiments [68]-[75].

It is necessary to point out that theta, alpha, beta, gamma, and other brainwaves are just one groups of brainwaves. There are lot of other brainwaves which come from the resonances with other vibrations in the universal vibrational field.

One may be curious about why the body developed the ability to resonate with SR. The reason could be that developing the ability to resonate with these vibrations enables the body to receive and send information, energy, and matter from and to the Earth as well as all other entities situated on this planet. For example, humans and other life forms such as plants and animals develop the ability to resonate with and receive visible light, which carries information, energy, and matter from the sun through these vibrations. Living systems develop critical abilities to resonate with and receive various vibrations from and to each other as

well as the Earth, sun, galaxies, and the universe. This information, energy, and matter can be vital for survival, vitality, health, well-being, immunity, communication, inspiration, purpose and meaning of life, and for physical, mental, emotional, and spiritual health and development. Being able to resonate with these vibrations can also help one to connect with each other, the Earth, sun, galaxy, and universe. This can enable life and consciousness to advance to higher levels, which involve ever-greater degrees of connection, order, synchrony, and complexity. This could be an important research direction to further probe the mysteries of the brain, consciousness, and life in general.

4.4. Study Brain's Neural Network as a Quantum Information System

According to QTOC, we need to study the brain's neural network as a quantum information system. Recent years have seen great progress in the research of quantum information theory [77], which is not only at the heart of modern information technology, but also provides new angles, tools, and methods in many areas. Here we apply it to study neural networks.

Quantum information science provides an information-theoretic understanding of correlation, especially the new concepts called "quantum entanglement" and "entanglement entropy." Normal entropy measures the degree of disorder and uncertainty existing within an object. Entanglement entropy measures the connection, correlation, and coherence existing within an object or between objects. Thousands of research papers studying the properties of quantum entanglement have been published in the past two decades. The main result is that the interaction and connection among neighboring units (e.g., spins, electrons, protons, atoms, molecules, neurons, cells, synapses) can lead to entanglement and bring about long-range order and various phase transitions. Some of the new phase states are nothing but the patterns of many-body entanglement. The nontrivial patterns of entanglement are the root of many highly novel phenomena in condensed matter [77].

Any quantum system inevitably interacts with the environment and leads to decoherence. To protect a system against noise, quantum error-correcting codes are developed. The main idea of the error-correcting codes is *to spread* the one qubit quantum information onto a highly entangled state of several qubits. In this way, errors caused by decoherence from the environment can be corrected or reduced.

Research in the formation of memory in the brain indicates that memory is the reactivation of a specific group of neurons, formed from persistent firings that lead to changes in the strength of connections between neurons. Since Karl Lashley's experimental work in the 1940s, it has been known that many functional activities of the brain cannot be directly related to specific neural cells; rather, they involve extended regions of the brain [78] [79]. The description of nonlocality of brain functions, especially of memory storing and recalling, was the main goal of the quantum brain model proposed in 1967 by Ricciardi and

Umezawa [33], which is based on the quantum field theory (QFT) of many-body systems. The extension of the model to dissipative dynamics has been recently investigated [9] in relation to the possibility of modeling neural networks exhibiting collective dynamics and long-range correlations among the net units.

From the quantum information theory point of view, the rich structures inside proteins, DNA, microtubules, membranes, neurons, and neural network give rise to entanglement, coherence, and correlation. Instantaneous and coherent firings in the brain's neural network are critical for forming the connections and interaction among neurons. These interactions can establish new entanglement and coherence, which can lead to special states or phase transition. From the quantum information theory point of view, memory corresponds to the unique new entangled states and the phase transition to a new coherent state.

It is interesting to notice that our brain has developed and is naturally using quantum error correction codes to protect memory. Each neuron contains thousands or tens of thousands of synapses, which are connected through the same cell body thus is quantum entangled. Each of synapse can take on the same quantum info. All the synapses in each neuron can hold copies of the same quantum information. In this way, quantum information is spread onto a highly entangled state of several pieces. In this way, errors caused by decoherence from the environment can be corrected or reduced. The neural system uses error-correcting code to protect the entanglement and the memory.

Quantum entanglement exists not only on the neuronal level; it is also prevalent at the vibrational level. It is critical for understanding brainwaves and their relationship with consciousness, brain structures and functions, as well as DNA structure, functions, and expression. Studying the brain's neural network, DNA, and life system as a quantum information system may lead to deeper and greater breakthrough in studying consciousness and life in general.

5. Discussion and Conclusion

In this paper, we suggest that consciousness is a quantum phenomenon. The solution of quantum measurement problem can lead to the solution of hard problem of consciousness. We propose a quantum theory of consciousness (QTOC) based on a new interpretation of quantum physics. In this QTOC, everything arises from a vibrational field carrying matter, energy, and information, which can be mathematically described in terms of wavefunction. Conscious experience occurs through the activation and application of body that can receive vibrations via resonance or information, energy, and matter. This QTOC provides the physics foundation and mathematical formulation to:

1) Address the hard problem of consciousness.

2) Develop various models of consciousness and extend existing theories.

3) It predicts the existence of a universal quantum vibrational field, which everything can access, receive, and send information, energy, and matter.

4) Explain the large-scale and almost instantaneous synchrony of brainwaves such as gamma, beta, and alpha brainwaves and why and how these brainwaves

are correlated with Schumann Resonances, as well as why and how such coherence can happen not only between different parts of brain and body, but also external objects, earth, sun, and even galaxies and the universe.

5) Apply current progress on quantum information theory—especially the insight about quantum entanglement and quantum error correction codes—to study the brain's neural network and shed new light on neuroscience, for example on the mechanism of memory.

We conclude that this quantum theory of consciousness (QTOC) warrants further discussion and development. We refer more detailed application and testing of this QTOC to future work. We welcome comments, discussion, and collaboration.

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Conflicts of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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