Resolution of Brain-Based Consciousness as a Quantum Information Field

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Abstract

This work resolves the brain-based consciousness as an Open Quantum Information Field, created and influenced via the environmental sensory information and operating under the full control of quantum mechanics. The external sensory information, modelled as quantised electromagnetic waves, is assumed to feed the cortical neurons and eventually construct the brain-based consciousness Hamiltonian. Any external energy/information, instantly reaching to the Hamiltonian of brain-based consciousness, is taken into account as a perturbation. In order to obtain instantaneous wave functions and probability amplitudes well known time dependant perturbation theory is employed. Quantum field theory is finally used to resolve the overall brain-based consciousness and some important conclusions are underlined.

Keywords: Resolution of Brain; Quantum Information Field; Consciousness Hamiltonian; Brain Based Consciousness.

1. Introduction

The human brain and exclusively the emergence of consciousness/mind are probably the most intricate concepts of modern sciences and philosophies (Descartes, 1641; Lotka, 1925; Heisenberg, 1958; Bohr, 1958, 1963; Bohm and Hiley, 1993; Chalmers, 1996; Appleby, 2013). Especially, the mysterious emergence of consciousness/mind and complicated functioning ever increasingly challenge not only neuroscientists, biologists or psychologists but whole scientific community indeed (Pribram, 1969, 1991; Eccles, 1973; Bass, 1975; Popper and Eccles, 1977; Hopfield, 1982; Pauen, 2001; Behera et. al. 2004; Zhang, 2011).

The present work specifically focuses on physically resolving the enigmatic connection between the physical brain and consciousness/mind by considering the consciousness/mind as a pure brain-based materialistic concept. Consciousness is defined as the dynamic self-awareness concept, constructed by the brain's cortical neurons as a quantum information field that continuously receives information/energy from the brain, evaluates and processes the information and initiates the responses. The approach, in this work, briefly considers that the all environmental sensory information is transformed into the quantised electromagnetic waves, reaching to the cortical neurons by action potentials carrying unique and modified information/energy. This unique information/energy then transferred into the ordered water molecules of the cytoplasm of the cortical neurons and varies the quantum physical state of the water molecules through the well-known quantum mechanical perturbation process and creates additional Nambu Goldstone Bosons, here called Consciousness-on/Con, creating and simultaneously influencing the Quantum Information Field that is in fact the Consciousness/mind.

In order to resolve the brain-consciousness phenomena, several classes of approaches have been managed in the past. Those approaches have the congenital difficulty of never giving emergence of the higher brain functions or consciousness like phenomenon (Zhang, 2011). The scientific research focusing on the resolution of brain and consciousness by using classical physical laws achieved incredible progress on the brain but almost nothing on the mind/consciousness (Parent and Carpenter, 1995; Ricciardi and Umezawa, 1967). In order to consider the consciousness as a physical concept, it has to be comprised of either energy or matter and it has to be a concrete concept that is purely measurable. Nowadays, quite a number of quantum physicist, neuroscientist, psychiatrists and biologists are aware of the scientific connection between quantum physics and

brain or consciousness leading to some distinct scientific efforts (Penrose, 1989,1994; Abbot et. al., 2008; Eisert and Wiseman, 2007; Arndt et. al., 2009; Isart , 2010; Erol, 2010a, 2010b).

Considering the quantum approaches to the brain-consciousness phenomena, some specific works surely move forward. Ricciardi and Umezawa, suggested that brain functions could be the result of a brain quantum field and have thus proposed a quantum model where the elementary constituents of the brain exhibit coherent behavior and macroscopic observables are derived as dynamical output from their interaction. In the quantum model of Ricciardi and Umezawa, the elementary constituents are not the neurons and the other cells and physiological units, which cannot be considered as quantum objects but some dynamical variables, called Corticons, able to describe stationary or quasi-stationary states of the brain (Ricciardi and Umezawa, 1967). Penrose suggested that consciousness/mind could not have been functioned in accordance with the principles of classical physics. This view would reaffirm the quantum theory that is a conscious human being behaves in ways that a classical mechanical model cannot fulfill (Penrose, 1986, 1989, 1994). Penrose and Hameroff later suggested subjective wave function reduction or more specifically orchestrated objective reduction model, happening in the microtubules of the neurons (Penrose,1989; Hameroff and Penrose, 1996). Marshall (1989) realized that Bose-Einstein Condensation could be a reality in brain functioning and responsible for the unified and singular structure of the consciousness/mind (Inouye et. al, 1999). One of the most radical suggestions came from Stapp in 1991, assumed that the only reality actually is the human consciousness/mind and only conscious actions results in the wave function collapse (Stapp, 1991,1993, 2001). In 1990, Eccles offered that mind and brain interconnected with a physical quantum field and the brain functions can be modeled with field quanta called Psychon (Eccles, 1990). Later together with Beck, they offered quantum tunneling of Pychons through the synaptic connections causing the coherence of the wave functions (Beck & Eccles, 1992). Jibu and Yasue have proposed to interlace the ideas of Pribram and Umezawa into a unified quantum theory of brain dynamics. Their theory takes the substrate associated with Umezawa's views to be the water that pervades the brain. Excitations of certain states of the water system are called Corticons, super radiance of evanescent photons, and they interact with photons in the electromagnetic fields of the dendritic network. They say: "with the help of quantum field theory, we have found that the creation and annihilation dynamics of Corticons and photons in the quantum brain dynamics system in the sub microscopic world of the brain to be the entity we call consciousness or mind" (Jibu and Yasue, 1995, 1997). The quantum model of the brain proposed by Ricciardi and Umezawa is extended to dissipative dynamics in order to study the problem of memory capacity by Vitiello. In his work, it is shown that infinitely many vacua are accessible to memory printing in a way that in sequential information recording the storage of a new information does not destroy the previously stored ones, thus allowing a huge memory capacity. The mechanism of information printing is shown to induce breakdown of time-reversal symmetry (Vitiello, 1995, 2001; Freeman and Vitiello, 2006, 2008).

In order to build a strong base to the quantum mechanical approach to the brain-consciousness phenomena, a great deal of experimental works provides evidences of quantum effects relating the living matter. For instance, an unexpectedly long-lasting quantum coherence in the electron transfer which is involved in photosynthesis (Engel et al., 2007; Lee et al., 2007; Collini et al., 2010; Panitchayangkoon et al., 2010, 2011; Sarovar et al., 2010). Another example of quantum dynamics in living systems has been found in photoreceptors. Experiments using high-resolution spectroscopic and nuclear-magnetic resonance techniques revealed coherent quantum waves in the rhodopsin molecule (Wang et al., 1994; Loewenstein, 2013). Concerning olfactory system, electron tunneling has been suggested to play an important role in the detection of odorants by olfactory receptors (Huelga and Plenio, 2013). Long-lived quantum entanglements in the cryptochromes of the retina seem to support the sensitivity of a bird's eye to magnetic fields (Arndt et al., 2009; Ball, 2011; Huelga and Plenio, 2013). Recent simulations show that quantum mechanical coherences in cryptochrome models can account for the precision of the avian magnetic compass (Hiscock et al., 2016). In addition, quantum tunneling has been observed in other

biomolecules, such as enzymes (Klinman and Kohen, 2013) or motor proteins (Hunter, 2006). Most importantly, contrary to the long-held view, under some conditions, the strong coupling to the noisy and warm environment is able to promote rather than hinder long-lasting quantum coherence in biological systems (Plenio and Huelga, 2008).

2. Quantised Electromagnetic Field as the Source of Information

The external sensory information (visual, hearing, touching, tasting and smelling) is certainly unique for every person at every instant and the uniqueness must be somehow included, defined and transferred to the brain. It is neurologically well-known fact that whatever the external unique information/stimuli, it is transferred to the brain's cortical neurons by means of certain action potentials, electrical voltage pulses. The spatial and temporal dependence of any electromagnetic potential can electro dynamically be described by a vector potential of ***A(r,t)***. The time and space dependent vector potential ***A(r,t),*** in any case, must be obeying to the most general classical wave equation, that is,

$$\nabla^2 \boldsymbol{A}(\boldsymbol{r},t) = \frac{1}{v^2}\frac{\partial^2 \mathbf{A}(\mathbf{r},\mathrm{t})}{\partial t^2} \qquad (1)$$

where ∇^2 denotes the Laplace Operator, v denotes the propagation group velocity of the waves, r denotes the position and t is time and the general solution can simply be given by,

$$\boldsymbol{A}(\boldsymbol{r},t) = \boldsymbol{A_t A_r} + \boldsymbol{A_t^* A_r^*} \qquad (2)$$

In the equation, $\boldsymbol{A_r} = A_r(0)e^{ikr}$, denotes the position dependant vector potential and $\boldsymbol{A_r^*}$ denotes the relevant complex conjugate, $\boldsymbol{A_t} = A_t(0)e^{-iw_k t}$ describes time dependence and $\boldsymbol{A_t^*}$ denotes the complex conjugate. The angular frequency for the wave vector k, that is $\omega_k = vk$, is assumed for a non dispersive situation for simplicity. Additionally, A_t^* and A_r^* expressions are, in fact, quantum mechanically associated with the annihilation and creation operators, respectively.

The vector potential defined above is the physical source of the spatial and temporal dependant electromagnetic waves propagate through the axons of the nervous system and any environmental information is transferred to the cortical neurons by means of these electromagnetic waves. Additionally, the electromagnetic waves must be quantized because of being physically confined within the volume of the relevant cortical neuron. The quantization is also important in order to be able to carry the huge number of sensory information. In general, many different modes of **k** and polarization of j will be generated by the vector/action potentials, depending on the complicated environmental conditions/information. Physically each mode of **k** specifies a new harmonic oscillator with the frequency of ω_k, into which any number of bosons/photons, n_k, can be created/added, $(n_k: 0 \rightarrow +\infty)$.

Similar to the vector potentials, environmentally created electromagnetic field is of course primarily maintained by the classical wave equation and the expression for the electrical field is given by,

$$\nabla^2 \boldsymbol{E}(\boldsymbol{r},t) = \frac{1}{c^2}\frac{\partial^2 \boldsymbol{E}(\boldsymbol{r},t)}{\partial t^2} \qquad (3)$$

In this expression, c denotes the velocity of the light in vacuum. The magnetic field counterpart can surely be written equivalently. The straightforward solution of the classical equations yield the time and position dependant electric field and magnetic field expressions as follows,

$$\boldsymbol{E}(\boldsymbol{r},t) = \boldsymbol{E_t E_r} + \boldsymbol{E_t^* E_r^*} \qquad (4)$$

$$\boldsymbol{B}(\boldsymbol{r},t) = \boldsymbol{B_t B_r} + \boldsymbol{B_t^* B_r^*} \quad (5)$$

where, $\boldsymbol{E}_r = E_r(0)e^{\boldsymbol{ikr}}$ represents the position dependant electric field expression and $\boldsymbol{E}_t = E_t(0)e^{-iw_k t}$ denotes the time dependant general expression of the electric field, $E_r(0)$ denotes the initial electric field parameter, similarly $B_r = B_r(0)e^{\boldsymbol{ikr}}$ and $B_t = B_t(0)e^{-iw_k t}$ represent the magnetic field counterparts. Meanwhile, E_t^* and E_r^* denote the complex conjugates. Spatial electrical field and magnetic field vectors, on the other hand, can clearly be written as,

$$\boldsymbol{E_r} = E_r(0)e^{\boldsymbol{ikr}}\boldsymbol{u_e} \quad (6)$$

$$\boldsymbol{B_r} = B_r(0)e^{\boldsymbol{ikr}}\boldsymbol{u_e x u_k} \quad (7)$$

where $\boldsymbol{u_e}$ is the unit vector specifies the direction of the electric field and $\mathbf{u_k}$ is the unit vector for the propagation direction that is the direction of **k** and satisfying $\boldsymbol{u_e u_k} = 0$.

At this point, we introduce the quantization of the electromagnetic fields, that means many modes depending on the environmental state is simultaneously superimposed at the same point, with the total quantization energy of $\hbar\omega_k$, where $\hbar$ denotes the reduced Planck's constant and ω_k denotes the angular frequency for the mode defined by the **k**. Furthermore, the spatial electrical function $\boldsymbol{E_r}$ can be chosen to have the normalization within the finite volume of the relevant cortical neuron that is V_0. If we average over the electromagnetic energies with time then the overall energy carried by the electrical field ought to be equal to the energy carried by the magnetic field. The external energy carried by the electromagnetic waves must be conserved and also quantized due to the confinement within the volume of the relevant neuron. Hence the overall electrical and magnetic energies then can be normalized by,

$$\frac{1}{2}\epsilon \int_0^{V_0} |E_r|^2 dV = \langle n_k \rangle \hbar\omega_k \quad (8)$$

$$\frac{1}{2\mu}\int_0^{V_0} |B_r|^2 dV = \langle n_k \rangle \hbar\omega_k \quad (9)$$

where $\langle n_k \rangle$ denotes the average occupation number of the states by the bosons created by the electromagnetic waves for the mode of $\omega_k = vk$ and simply given by

$$\langle n_k \rangle = \frac{1}{e^{\frac{\hbar\omega_k}{kT}} - 1} \quad (10)$$

In the expression, $\epsilon = \epsilon_0\epsilon_r$ being the electrical permittivity and $\mu = \mu_0\mu_r$ is the magnetic permittivity. The sensory neurons simply transform the external stimuli/information to certain quantized electromagnetic fields within the finite size of the sensory neurons, V_0. The normalization condition only works in a finite volume of V_0 even though the results are more generally true even in a vacuum of infinite size, so the initial electric field and magnetic field parameters can be found from the normalization conditions as,

$$E_r(0) = \sqrt{\frac{2\langle n_k \rangle \hbar\omega_k}{\epsilon V_0}} \quad (11)$$

$$B_r(0) = \sqrt{\frac{2\mu\langle n_k \rangle \hbar\omega_k}{V_0}} \quad (12)$$

The volume V_0 is arbitrary as it does not ultimately influence the Hamiltonian and momentum, but the size of the neuron can be chosen for simplicity as a cubic box of side length L with periodic boundary conditions; these conditions restrict the allowed values of **k** to be $k = \frac{2\pi}{L} n_j$ where n_j is the relevant quantum number for the specific mode **k** and polarization j, a positive integer. The polarization is the other very important physical parameter for the electromagnetic waves and taking into account two linear independent solutions $\mathbf{u}_{(\mathbf{k},i)}$ and $\mathbf{u}_{(\mathbf{k},j)}$ satisfying $\mathbf{u}_{(\mathbf{k},i)}$ $\mathbf{u}_{(\mathbf{k},j)}=\delta_{ij,}$ the unit vectors describe two independent polarizations of the waves, namely horizontal and vertical polarizations.

The electromagnetic wave modes are no longer indexed only by the wave vector k, but must also embrace the polarization j. Hence, the electromagnetic fields for a given mode (**k**;j) and assuming $E_t(0) = 1$ and $B_t(0) = 1$, can be expressed by,

$$\boldsymbol{E}_{\boldsymbol{k},j}(\boldsymbol{r},t) = \sqrt{\frac{2\langle n_k\rangle \hbar\omega_k}{\epsilon V_0}}\left(e^{ikr}e^{-iw_k t} + e^{-i\boldsymbol{kr}}e^{iw_k t}\right)\boldsymbol{u}_{\boldsymbol{e},j} \tag{13}$$

$$\boldsymbol{B}_{\boldsymbol{k},j}(\boldsymbol{r},t) = \sqrt{\frac{2\mu\langle n_k\rangle \hbar\omega_k}{V_0}}\left(e^{ikr}e^{-iw_k t} + e^{-i\boldsymbol{kr}}e^{iw_k t}\right)\boldsymbol{u}_{\boldsymbol{e},\boldsymbol{j}}\boldsymbol{x}\boldsymbol{u}_{\boldsymbol{k},\boldsymbol{j}} \tag{14}$$

and the electric and magnetic field operators accounting for all modes. The overall electromagnetic fields are the sums of the individual modes,

$$\boldsymbol{E}(\boldsymbol{r},t) = \sum_{\boldsymbol{k},j} \boldsymbol{E}_{\boldsymbol{k},\boldsymbol{j}}(\boldsymbol{r},t) \tag{15}$$

$$\boldsymbol{B}(\boldsymbol{r},t) = \sum_{\boldsymbol{k},j} \boldsymbol{B}_{\boldsymbol{k},\boldsymbol{j}}(\boldsymbol{r},t) \tag{16}$$

The equations above are the overall quantised electric and magnetic fields physically carry all the environmental information to the cortical neurons, eventually to the mind/consciousness. The initial information/energy transfer to the cortical neurons is realised by the interaction between the quantised electromagnetic field and ordered water molecules of the cortical neurons.

3. Hamiltonian of Brain-Based Consciousness

The interaction between the ordered water dynamical system and externally derived electromagnetic field is considered to be decisive for the emergence of *quantum consciousness* (Jibu & Yasue, 1995, 1997; Georgiev, 2002, 2003). It is, in fact, obvious that there must be a mechanism for conversion of the entering external sensory information to the electrophysiological information down to the molecular level, specifically into quantum coherent states, creating the quantum information field in other words the actual mind/consciousness (Ricciardi & Umezawa, 1967; Mensky, 2014). The uniqueness of the brain is surely due to the organization of the overall body in the sense that the sensory system is organised to feed the brain with the external sensory information. Hence the data reaching to the brain puts it to a distinct position comparing the rest of the material world.

The ultimate functioning of the brain is assumed to be determined by the *Hamiltonian* of the ordered water molecules within the cytoplasm of the cortical neurons. In order to resolve the consciousness quantum mechanically one needs to define the actual Hamiltonian. Water molecules have a Hamiltonian due to the molecular structure, that means $H_{H_2o} = H_{h1} + H_{h2} + H_o$ and the Hamiltonian in this expression includes all terms namely, the kinetic energies of the electrons and the electrical potential energies of the electrons. The overall Hamiltonian of the water due to inter molecular and inter atomic structure has a fixed and *time independent* term and assumed to be not interacting with the external electromagnetic field at all. Concerning the external stimuli or quantised electromagnetic field, the water molecules with a molecular mass of M_{H_2o} surely vibrate

due to the temperature, very similar to the harmonic oscillator situation. In order to resolve the interaction between the external quantised electromagnetic waves and the ordered water molecules one needs to primarily write down the overall Hamiltonian. The overall Hamiltonian of the interaction between the external stimuli that is the quantised electromagnetic field and ordered water molecules has mainly two components namely; time independent harmonic oscillator term (H_0) and the time dependant interaction term (H_I) ,

$$H = H_0 + H_I \qquad (17)$$

Hence, the overall Hamiltonian of any water molecule must include the harmonic oscillator term due to the thermally derived vibrations. Hamiltonian of the harmonic oscillator in the classical form is simply given by,

$$H_0 = \frac{p^2}{2m} + \frac{m{\omega_0}^2 r^2}{2} \qquad (18)$$

This expression basically assumes that water molecules own a singular vibration frequency, ω_0 and the mass m represents the mass of the water molecules, m=M_{H_2O} and p denotes the linear momentum of the molecule. This expression can also be given in the operator form in quantum mechanics by means of the well known creation, $\hat{a}^\dagger$ and annihilation, $\hat{a}$, operators; that is,

$$H_0 = \hbar\omega_0(\hat{a}^\dagger\hat{a} + \frac{1}{2}) \qquad (19)$$

This equation is set to be time independent and does not interact with the electromagnetic waves because of being just the mass based term. The Eigen values and the Eigen functions for the harmonic oscillator are very well known and given by,

$$E_n^0 = \hbar\omega_0(n + \frac{1}{2}) \qquad (20)$$

$$\psi_n^0(r) = \frac{1}{\sqrt{n!}}\left(\frac{m\omega_0}{\pi\hbar}\right)^{1/4}\left(\sqrt{\frac{m\omega_0}{2\hbar}}r - \sqrt{\frac{\hbar}{2m\omega_0}}\frac{d}{dr}\right)^n e^{\frac{-m\omega_0 r^2}{2\hbar}} \qquad (21)$$

In the expressions above, E_n^0 is the total mechanical energy of the quantum state of n for the unperturbed case and $\psi_n^0(r)$ denotes the only space dependant wave function for the unperturbed quantum state of n. The unperturbed case physically means no external stimuli or information arrives to the cortical neurons and hence to the water molecules, therefore one can easily consider that, $H_I = 0$.

The second term of the total Hamiltonian is instantly time and position dependant, $H_I = H_I(r,t)$, represents the mutual interaction between the external quantized electromagnetic waves and electrical and magnetic dipole moments of the water molecules. Hence, the interaction Hamiltonian is comprised of two terms namely the electrical interaction and the magnetic interaction terms. Then the overall interaction Hamiltonian can be given by the sum of the two terms,

$$H_I(r,t) = H_I^E(r,t) + H_I^B(r,t) \qquad (22)$$

The interaction of the external electric field and the electrical dipole moment in simplest form is very strongly time and space dependant and is written by,

$$H_I^E(r,t) = -\boldsymbol{\mu_e}\boldsymbol{E}(\boldsymbol{r},t) \qquad (23)$$

or in more detailed form is written by

$$H_I^E(r,t) = -\boldsymbol{\mu_e} \sum_{k,j} \sqrt{\frac{2\langle n_k \rangle \hbar\omega_k}{\epsilon V_0}} \left(e^{i\boldsymbol{kr}} e^{-iw_k t} + e^{-i\boldsymbol{kr}} e^{iw_k t}\right) \boldsymbol{u_{e,j}} \qquad (24)$$

This electrical interaction Hamiltonian is highly dependent on the distribution of the angle θ between the electrical field, assumed to be in the z direction, and the actual electrical dipole orientation, hence one needs to calculate the mean value to reach a meaningful interaction Hamiltonian. The Hamiltonian is then just determined by the electrical field component of the dipole moment as a result of the scalar product, that is $\mu_e^z = \mu_e cos\theta$ denotes the z component of the electrical dipole moment. Employing the classical Maxwell Boltzmann distribution function, one can easily calculate the mean value of the cosine of the angle θ which approaches to the well known Langevin function; that is;

$$\langle cos\theta \rangle = L(x) = cothx - \frac{1}{x} \qquad (25)$$

where $x = \frac{\mu_e E}{kT}$ where k denotes the Boltzmann's Constant and using x $\ll$ 1 approach yields the Langevin function to $\frac{x}{3}$ and the mean value of the z component of the electrical dipole moment is given by,

$$\langle \mu_e^z \rangle = \mu_e \langle cos\theta \rangle = \frac{{\mu_e}^2 E(r,t)}{3kT} \qquad (26)$$

It is now straightforward to extract the overall Hamiltonian due only to the external electric field component of the quantized electromagnetic fields; that is,

$$H_I^E(r,t) = -\frac{{\mu_e}^2 E^2(r,t)}{3kT} \qquad (27)$$

In analogous with the electrical interaction described above, the Hamiltonian term due to the interaction between the magnetic moment and the external magnetic field is given by,

$$H_I^B(r,t) = -\boldsymbol{\mu_b} \boldsymbol{B_{k,j}}(\boldsymbol{r},t) \qquad (28)$$

and the magnetic interaction Hamiltonian is given by.

$$H_I^B(r,t) = -\boldsymbol{\mu_b} \sum_{k,j} \sqrt{\frac{2\mu\langle n_k \rangle \hbar\omega_k}{V_0}} \left(e^{i\boldsymbol{kr}} e^{-iw_k t} + e^{-i\boldsymbol{kr}} e^{iw_k t}\right) \boldsymbol{u_{e,j}} \times \boldsymbol{u_{k,j}} \qquad (29)$$

where $\boldsymbol{\mu_b}$ denotes the overall magnetic moment of the water molecules. The magnetic moment of the water molecules is due to the orbital and spin movements of the electrons within the atoms, namely two H and one O atom. Hence both spin and orbital magnetic moments ought to be taken into account. Therefore, the overall magnetic moment term $\boldsymbol{\mu_b}$ includes both the orbital $\boldsymbol{\mu_l}$ and spin $\boldsymbol{\mu_s}$ movements of the electrons, hence it can be written by,

$$\boldsymbol{\mu_b} = \boldsymbol{\mu_l} + \boldsymbol{\mu_s} \qquad (30)$$

Similarly, what counts here, concerning the overall magnetic interaction Hamiltonian and of course the interaction energy, is the magnetic field direction, that is z, of the magnetic moment; which is,

$$\mu_b^z = \mu_b cos\theta \qquad (31)$$

In order to get an expression for the overall interaction Hamiltonian, one needs to calculate the expectation/mean value of the z component of the magnetic moment. To do so again the classical Maxwell-Boltzmann distribution function is used through the well known *Partition Function* and the definitions of the mean value. The final result is given by the *Brillouin Function*, $B_j(x)$, that is,

$$\langle \mu_b^z \rangle = gj\mu_B B_j(x) = \mu_b B_j(x) \qquad (32)$$

where $x = \frac{\mu_b B}{kT}$ and μ_b denotes a unit magnetic moment, $\mu_b = gj\mu_B$; g is the Lande factor, J denotes the total angular momentum quantum number and μ_B states the Bohr magneton. Using x $\ll 1$ limit condition yields the Brillouin Function approaching to $B_j(x) = \frac{x}{3}$ similar to the Langevin function. This leads the z component of the overall magnetic moment to the result of,

$$\langle \mu_b^z \rangle = \frac{{\mu_b}^2 B(r,t)}{3kT} \qquad (33)$$

The final conclusion for the interaction Hamiltonian between the magnetic field component of the external magnetic field and the overall magnetic moment, that is the orbital and spin magnetic moments together,

$$H_I^B(r,t) = -\frac{{\mu_b}^2 B^2(r,t)}{3k} \qquad (34)$$

The expression for the interaction Hamiltonian is given by,

$$H_I(r,t) = -\frac{{\mu_e}^2 E^2(r,t)}{3kT} - \frac{{\mu_b}^2 B^2(r,t)}{3kT} \qquad (35)$$

Overall, the Hamiltonian relating the water molecules interacting with the external stimuli or quantized electromagnetic waves is given by.

$$H(r,t) = \hbar\omega_0 \left(\hat{a}^\dagger \hat{a} + \frac{1}{2}\right) + \left[-\frac{{\mu_e}^2 E^2(r,t)}{3kT} - \frac{{\mu_b}^2 B^2(r,t)}{3kT}\right] \qquad (36)$$

In the final expression above, the individual electrical dipole moment for the water molecules is measured to be about $\mu_e = 2ed = 9{,}85\,.\,10^{-30} Cm$ at about room temperatures. And the overall magnetic moment including the orbital and spin components is measured to be about $\mu_b = 2.45.10^{-3}\ J/T$ again at room temperatures, T denotes the body temperature which is about 309,6 K.

4. Time Dependant Perturbation Approach to Brain-Based Consciousness

Human beings continuously receive huge number of signals from the surroundings by touching, smelling, tasting, seeing and hearing through the sensory organs and also via the internal neuron networks from the inner body. All that information is eventually converted to specific quantized electromagnetic waves as formulated previously and reaches to the network of the relating cortical neurons. The cortical neurons within the cytoplasm are shaped by the cytoskeleton structures that are surrounded the ordered water molecules which exhibit very interesting physical and chemical properties as summarized previously. Continuously arriving external information makes the brain physically an open system which must be treated very carefully. Therefore the

brain ought to be considered as an open quantum information system physically stable unless an external information or energy arrives. Hence, any external information can surely be considered as a *perturbation* term that influences the overall energy/field of the consciousness which is expressed by the actual Hamiltonian. Previously it was suggested that, highly ordered water molecules within the cytoplasm, maintaining macroscopic electrical and magnetic dipoles, interact with the quantized electromagnetic fields that lead to the generation of Nambu-Goldstone bosons/cons, which are long-range coherence mediating quanta in accordance with the well known Quantum Field Theory (Jibu et.al. 1997). The created Nambu-Goldstone bosons build the Quantum Information Field which is, in fact, equivalent to the Consciousness and named as Consciousness-on abbreviated as "Con" throughout this work.

The present work offers that the specific quantized electromagnetic waves interacting with the ordered water molecules through the well known time dependant perturbation. The Hamiltonian for the ordered water molecules, which are thought to be responsible for the cellular activities through the cytoskeleton structures, ought to have two terms namely the *harmonic oscillator term* and the *perturbation term*. Hence the overall Hamiltonian for any water molecule can be expressed by,

$$H = H_0(r) + H_I(r,t) \qquad (37)$$

where $H_0(r)$ denotes the stable and time independent part of the water molecules which simply equals to the harmonic oscillator Hamiltonian, defined by the equation (19), $H_I(r,t)$ represents the perturbation term which is very strongly time dependant and purely determined by the external information or the external *quantized electromagnetic waves* resolved previously and given by the equation (35). The Hamiltonian in fact expresses the instant state of the global personal consciousness. Any information/stimuli arrives at the cortical neurons influences the interaction Hamiltonian term and varies the consciousness as a perturbation. The wave functions accompanying the bosons/cons and specifying the physical behavior for the unperturbed stable situation, is simply given by the time independent Schrödinger equation that is,

$$H_0(\mathrm{r})\psi_\mathrm{n}^0(\mathrm{r}) = \mathrm{E}_\mathrm{n}^0\psi_\mathrm{n}^0(\mathrm{r}) \qquad (38)$$

where E_n^0 is the total mechanical energy of the quantum state of n for the unperturbed case, previously given by (20) and $\psi_\mathrm{n}^0(\mathrm{r})$ denotes the relevant space dependant wave function is given by the equation (21) previously. Overall time and space dependant wave functions for the unperturbed situation is given by the well known superposition of the unperturbed wave functions, including a time independent complex parameter, c_n ,

$$\Psi(r,t) = \sum_{n=0}^{\infty} c_n\psi_\mathrm{n}^0(\mathrm{r})\exp[-\tfrac{\mathrm{iE}_\mathrm{n}^0\mathrm{t}}{\hbar}] \qquad (39)$$

Any external information/energy reaching to the brain's cortical neurons influences the Hamiltonian and the mind/consciousness as a perturbation and accordingly creates a Nambu Goldstone Boson/Con and those bosons are physically accompanied by the waves defined above. In the expression above, the complex coefficient c_n denotes the occurrence probability amplitude for the quantum state of n. The overall Hamiltonian including the unperturbed and interaction terms then must be complied with the time and space dependant Schrödinger Equation which is given by,

$$i\hbar\frac{\partial}{\partial t}\Psi(r,t) = [H_0(r) + H_I(r,t)]\Psi(r,t) \qquad (40)$$

The general solution of the time and space dependant Schrödinger Wave Equation is simultaneously composed of all the possible states and is given by,

$$\Psi(r,t) = \sum_{n=0}^{\infty} c_n(t)\psi_{\mathrm{n}}^{0}(\mathrm{r})\exp[-\frac{\mathrm{iE_n^0 t}}{\hbar}] \quad (41)$$

This expression simultaneously holds infinite possible quantum states just like the mind/consciousness and this property is known as the superposition principle. In the equation above $c_n(t)$ denotes the probability amplitude of the quantum state of n. The probability amplitude is time dependant, in fact, indicates the very complicated interaction between the environment and the overall Hamiltonian or consciousness/mind and describes the weight of the occurrence of a specific case within the overall possibilities. The energy term, $\mathrm{E_n^0}$, is the total mechanical energy of the quantum state of n for the unperturbed case and $\psi_{\mathrm{n}}^{0}(\mathrm{r})$ denotes the space dependant wave function for the unperturbed quantum state of n. Substitution of $\Psi(r,t)$ into the time dependant Schrödinger equation gives,

$$i\hbar\frac{\partial}{\partial t}\mathrm{c_n}(t) = \sum_{m=1}^{\infty} c_n(t)\langle H_I^{nm}(r,t)\rangle\exp[\frac{\mathrm{i}}{\hbar}(\mathrm{E_n^0 - E_m^0})\mathrm{t}] \quad (42)$$

where $\langle H_I^{nm}(r,t)\rangle$ denotes the mean/expected value of the time dependant interaction Hamiltonian for the consciousness/mind. Any instant information/energy reaching the consciousness/mind leads to a new expected/mean value which immediately changes the overall state. This purely time and externally dependant mean value actually expresses the rapidly changing human consciousness state and indeed psychology. The perturbation Hamiltonian can be averaged by the initial quantum state, m, and the final quantum state, n, through the transition process,

$$\langle H_I^{nm}(r,t)\rangle = \int_{-\infty}^{+\infty} \psi_{\mathrm{n}}^{0*}(\mathrm{r})H_I(r,t)\psi_{\mathrm{m}}^{0}(\mathrm{r})dV \quad (43)$$

The interaction Hamiltonian given above is the mean/expected value at any instant of t for the transition between the quantum states of m and n. The probability amplitude for the transition from the quantum state m to the final quantum state n due to the external stimulation is simply given by,

$$\mathrm{c_n}(t) = -\frac{i}{\hbar}\int_0^t \langle H_I^{nm}(r,\acute{\mathrm{t}})\rangle\exp[\frac{\mathrm{i}}{\hbar}(\mathrm{E_n^0 - E_m^0})\acute{\mathrm{t}}]\mathrm{d}\acute{\mathrm{t}} \quad (44)$$

This expression is very important in the sense that it describes the probability of being in the quantum state of n for the consciousness. Finally, actual probability for the transition from the quantum state m to the quantum state n is given by the squared amplitude,

$$P_n(t) = |c_n(t)|^2 \quad (45)$$

This is the term, offered by the well-known time dependant perturbation theory, is assumed to be maintained for the interaction of the consciousness/mind and the external information.

The environmental information/stimuli or energy primarily transformed to the quantized electromagnetic waves, described previously, eventually reaches to the ordered water molecules of the cortical neurons causing Nambu Goldstone Boson/Con emission in accordance with the energy conservation. Assuming that the external information creates a single boson and increases the number bosons by just one, then the following interaction Hamiltonian can be written for the process;

$$H_I = -\left(\frac{2{\mu_e}^2}{kT\epsilon V_0} + \frac{2{\mu_b}^2\mu}{kTV_0}\right)\sum_k(\langle n_k\rangle + 1)\hbar\omega_k\, e^{2i(\omega_k t - \boldsymbol{kr})} \quad (46)$$

In the equation above $(\langle n_k\rangle + 1)\hbar\omega_k$ represents the actual boson/con emission with the energy quanta of $\hbar\omega_k$. The external stimuli in fact instantaneous and of course continuous therefore

the boson/Con emission is called stimulated emission just like in the process of lasers. The sum is done over all the possible modes which is simply given by $k = \frac{2\pi}{L}n$, n is being the positive integer and the angular frequency can be given by $\omega_k = ck$. The number of modes obviously depends on the actual size of the relevant neuron. The overall interaction Hamiltonian is expressed by the superposition of all modes. The interaction or perturbation Hamiltonian includes a parameter representing the material specifications and it is represented by Z and is given by,

$$Z = \left(\frac{2{\mu_e}^2}{kT\epsilon V_0} + \frac{2{\mu_b}^2\mu}{kTV_0}\right) \qquad (47)$$

where V_0 denotes the neuron size, T is the absolute temperature, μ_e denotes the electrical dipole moment and μ_b specific magnetic dipole moment of the water molecules. The perturbation Hamiltonian due to the externally driven boson emission can now be written in a simpler form, that is,

$$H_I = -Z\sum_{k,j}(\langle n_k\rangle + 1)\hbar\omega_k\, e^{2i(\omega_k t - \boldsymbol{kr})} \qquad (48)$$

All the information arriving to the cortical neurons with the wave vector/mode k and polarization of j creates Nambu-Goldstone bosons/Cons with the boson energy of $\hbar\omega_k$ according to the Hamiltonian above. The interaction Hamiltonian is purely due to the external information created by the sensory organs and transferred to the cortical neurons via the synaptic network. The external sensory information flow to the mind/consciousness is surely continuous and varies with time very strongly. Therefore, the mean value of the interaction Hamiltonian is undoubtedly much more useful to understand the ongoing processes. The average of the Hamiltonian in fact describes the instantaneous state of the consciousness and consequently the psychology. The perturbation term by definition is averaged over the unperturbed stable Eigen functions for a single polarization (j=1) and given by,

$$\langle H_i^{nm}(r,t)\rangle = -Z\sum_k(\langle n_k\rangle + 1)\hbar\omega_k \int_{-\infty}^{+\infty}\psi_{\mathrm{n}}^{0*}(\mathrm{r})e^{-2i\boldsymbol{kr}}\psi_{\mathrm{m}}^{0}(\mathrm{r})dV \qquad (49)$$

The expression above indicates that the current state of the consciousness depends on the number of k modes coming from the outside, the average number of bosons and the expected /mean value of the waves accompanying the bosons. The occurrence probability amplitude of the quantum state of n depends on the interaction between the external quantized electromagnetic waves and the magnetic and electrical dipole moments of the cellular water molecules within the cytoplasm that is expressed by the time dependant coefficients which is given by,

$$\mathrm{c_n}(t) = \frac{iZ}{\hbar}\sum_k(\langle n_k\rangle + 1)\hbar\omega_k \left\langle\psi_{\mathrm{n}}^{0}(\mathrm{r})\middle|e^{-2i\boldsymbol{kr}}\middle|\psi_{\mathrm{m}}^{0}(\mathrm{r})\right\rangle \int_0^t \exp[\tfrac{2\mathrm{i}}{\hbar}(\mathrm{E_n^0} - \mathrm{E_m^0} + \hbar\omega_{\mathrm{k}})\acute{\mathrm{t}}]\mathrm{d}\acute{\mathrm{t}}$$
(50)

The equation above assumes that the photon with an energy of $\hbar\omega_{\mathrm{k}}$ in the mode of k, transfers the energy to a water molecule that has ordinary harmonic oscillator energy Eigen values of $\mathrm{E_n^0}$ and $\mathrm{E_m^0}$. The transition probability from the state m to the state n is simply given by the squared amplitude of the time dependant coefficient of, $\mathrm{c_n}(t)$,

$$\mathrm{P_n}(t) = Z^2\sum_k(\langle n_k\rangle + 1)^2{\omega_k}^2\left|\left\langle\psi_{\mathrm{n}}^{0}(\mathrm{r})\middle|e^{-2i\boldsymbol{kr}}\middle|\psi_{\mathrm{m}}^{0}(\mathrm{r})\right\rangle\right|^2\left|\int_0^t \exp 2\mathrm{i}[(\omega_{\mathrm{n}} - \omega_{\mathrm{m}}) + \omega_{\mathrm{k}}]\acute{\mathrm{t}}]\mathrm{d}\acute{\mathrm{t}}\right|^2$$
(51)

This equation essentially indicates that the probability of finding the consciousness/mind in the quantum state of n. The boson statistics offers no limit to the number bosons within any

quantum state hence an infinite number of bosons with coherent waves can be realised for n and this property gives the consciousness the power to function perfectly. The overall probability can be stated as the multiplication of four separate parameters in simpler manner,

$$\mathrm{P_n}(t) = Z^2 f(n_k) f_k(r) f_k(t) \qquad (52)$$

The first parameter influencing the state of the consciousness/mind, that is the probability, is the media term, that is,

$$Z^2 = \left[\left(\frac{2{\mu_e}^2}{kT\epsilon V_0} + \frac{2{\mu_b}^2\mu}{kTV_0}\right)\right]^2 \qquad (53)$$

This is the parameter determined by the electrical, magnetic and physical properties of the neurons. More specifically the physical volume of the neurons, temperature, magnetic and electrical dipole moments of the ordered water molecules, electrical and magnetic permittivity of the neurons describe the parameter. This parameter would be almost the same for everybody and individuality would make no difference.

The other parameter could be called as mode parameter and is given by,

$$f(n_k) = (\langle n_k \rangle + 1)^2 {\omega_k}^2 \qquad (54)$$

The modal parameter depends on the average number of bosons/Cons, that is n_k, created for the mode frequency of ω_k. This mode parameter is purely determined by the external wave vector of k and therefore highly experience dependant and expresses the individuality and uniqueness of the personal psychology and consciousness/mind.

The state of global personal consciousness/mind and therefore the probability expression $\mathrm{P_n}(t)$ also depends on a spatial parameter that is,

$$f_k(r) = \left|\langle \psi_{\mathrm{n}}^0(\mathrm{r}) \left| e^{-2i\boldsymbol{kr}} \right| \psi_{\mathrm{m}}^0(\mathrm{r}) \rangle\right|^2 \qquad (55)$$

This equation states spatial dependence of the state of global consciousness for any single mode of k. The parameter is determined by the unperturbed waves averaged between the initial state of m and the final state of n. The expectation value of the plane waves is also known as the matrix element and determines the position of the emitted photon. The position of the emitted photon is very crucial because it also determines the neuron or ensemble of neurons to ignite.

The last parameter can be named as the *time parameter* since it describes the time dependence of the consciousness/mind and simply averages the time dependence part of the Schrödinger waves. In the equation above the external stimuli injects the neuron system a specific quantised energy of $\hbar\omega_{\mathrm{k}}$ and the unperturbed harmonic oscillator system interact with the coming energy in the sense that when $\omega_{mn} = \omega_m - \omega_n = \omega_k$ then the frequency parameter, $\Delta_{\mathrm{k}} = 2[(\omega_{\mathrm{n}} - \omega_{\mathrm{m}}) + \omega_{\mathrm{k}}]$, equals to zero which results the time dependant factor, that is,

$$f_k(t) = \left|\int_0^t \exp[\mathrm{i}\Delta_{\mathrm{k}}\acute{\mathrm{t}}]\mathrm{d}\acute{\mathrm{t}}\right|^2 = \frac{4}{{\Delta_{\mathrm{k}}}^2} sin^2\left(\frac{\Delta_{\mathrm{k}}\mathrm{t}}{2}\right) \qquad (56)$$

equals to unity. This is the physical situation making the unperturbed consciousness/mind making a transition from the state m to the quantum state of n accompanied by the emission of a Nambu-Goldstone boson/Con with the energy of $\hbar\omega_{\mathrm{k}} = \hbar(\omega_{\mathrm{m}} - \omega_{\mathrm{n}})$ This is also the condition for the energy conservation, taking into account of the overall modes coming from the sensory organs as

the environmental information. Any single information results a boson/Con emission and all those bosons/Cons are assumed to build the actual consciousness for the human beings.

5. Emergence of Quantum Information Field

The approach employed in this work considers that the human brain is a unique organ in the sense that, it continuously receives the environmental information through the sensory organs and transfers the information to the consciousness in the form of quantised particles, bosons. The consciousness, as the ultimate control centre of the brain and hence human activities, is created by the brain as an epiphenomenon, more specifically via the interaction of the externally derived and quantised electromagnetic fields and the electrical dipole and magnetic moments of the water molecules within the cytoplasm of the cortical neurons (Ricciardi & Umezawa, 1967; Jibu &Yasue, 1997; Vitiello, 1995).

The process starts by receiving the external information via the sensory organs and internal information via the neuron network that are instantly converted to the *action potentials* or *neurotransmitters*. Standard *Maxwell Equations* eventually transform the action potentials to the quantised electromagnetic fields such that every single bit of information maintains the very individuality. The quantised electromagnetic fields instantaneously interact with the electrical and magnetic dipole moments of the water molecules within the cytoplasm concluding the transfer of the external energy/information to the relating cortical neurons. The water molecules of the cortical neurons accordingly create the specific *bosons* which are the quanta of the *Quantum Information Field (QIF)* creating the actual *consciousness/mind*. The quanta of the QIF could be named as Consciousness-on or shortly *'Con'*.

In order to analyse and model the consciousness/mind one surely needs to employ the standard Quantum Field Theory. To start with, a non-hermitian *consciousness operator*, *C,* ought to be defined in order to characterize the consciousness and it is accountable for the *creation* and *annihilation* of the *Cons* or so-called *Nambu-Goldstone Bosons.* The consciousness is actually created by our overall past experiences and affirms the uniqueness of the individual personality. Every single sensory data immediately transformed to quantized electromagnetic waves which adds up to the existing quantum field, consciousness/mind, by creation of a boson/con. The consciousness operator *'$\boldsymbol{C}$'* and its Hermitian conjugate *'C^+'* has the property of destroying one boson/Con or creating a boson/Con, with the function state $\Psi_{n_k}(r,t)$, respectively. The creation of a boson/Con due to the external information/energy is expressed by,

$$C_k{}^{+}\Psi_{n_k}(r,t)=\Psi_{n_k+1}(r,t) \qquad (57)$$

whereas the annihilation of a boson/Con is affirmed by,

$$C_k\Psi_{n_k}(r,t)=\Psi_{n_k-1}(r,t) \qquad (58)$$

In these equations, n_k denotes any quantum number or alternatively existing number of Cons/bosons or occupation number for the wave vector of k and $\Psi_{n_k}(r,t)$ represents the relevant wave function which, based on the previous chapters, can be written by,

$$\Psi_{n_k}(r,t) = c_{n_k}(t)\psi^0_{n_k}(\mathrm{r})\exp\left[-\mathrm{i}\omega^0_{n_k}\mathrm{t}\right] \qquad (59)$$

where $c_{n_k}(t)$, given previously, denotes the complex coefficient for the quantum state of n_k, and mode of k, $\psi^0_{n_k}(\mathrm{r})$ states the space dependant state vector for the unperturbed case given previously by (21) and $\omega^0_{n_k}$ denotes the angular frequency for the unperturbed state. This is the standard quantum field theory; the operators are known as ladder operators since they increase or decrease the occupation number of a state vector by just one every time. The full mental space

specifically due to the external information of k defining the mental Hilbert space $\{k\}$ (which is a truncated Hilbert space) can be given

$$\Psi_{\mathrm{k}}(r,t) = \sum_{\mathrm{n_k}=0}^{\infty} \Psi_{\mathrm{n_k}}(r,t) \qquad (60)$$

The consciousness is constructed and continuously altered by the externally driven sensory information which is expressed by simply the wave vector of k, hence global personal consciousness/mind consists of all the wave functions and can now be articulated by,

$$\Psi(r,t) = \prod_k \Psi_k(r,t) \qquad (61)$$

The states $\Psi_{\mathrm{k}}(r,t)$ are the independent linear orthogonal vectors of Fock Space defining the Hilbert space of consciousness while the orthogonal linear vectors $\Psi_{\mathrm{k}}(r,t)$ constitute the mental subspace of certain k modes. The operators $\{C_k\}$ are initiators of cognitive functions and are instruction protocols like all operators in quantum mechanics. Neurons are the conduits of mental action, not the other way around. Information functional space $\{\Psi_k(r,t)\}$ is to neurons what software is to the electronic hardware comprising a computer. The assembly of wave functions $\Psi_{\mathrm{k}}(r,t)$ constitutes the conceptual mental space on which our k-dependant mental life is constructed.

In addition to the creation operator, ${C_k}^+$, we have its conjugate identical, the corresponding annihilation operator, C_k , that has the instruction to destroy an existing boson in the mode of k, thus decreasing number of bosons/cons already existing in the state $\Psi_{\mathrm{n_k}}(r,t)$ by one. By definition the vacuum state itself is annihilated by its action on the actual wave function for all k values, $C_k\Psi_0(r,t)$=0. The joint action of these two operators can describe a third operator, could be named as *number operator*, $\hat{n}_k$ and maintains to count the number of bosons/Cons in a given neuron. The number operator together with the joint operation of the creation and annihilation operators can be described as,

$${C_k}^+ \mathrm{C_k} \Psi_{\mathrm{n_k}}(r,t) \;=\; \hat{n}_k \Psi_{\mathrm{n_k}}(r,t) = \Psi_{\mathrm{n_k}}(r,t) \qquad (62)$$

In the equation, $\mathrm{n_k}$ is just the occupation number or more specifically the number of Bosons/Cons involved with the wave number of k. The expression also indicates that the Eigen value for the number operator is simply equal to unity. The boson/Con creation and destruction operators can also be defined in terms of the overall wave function of $\Psi_k(r,t)$, comprised of all the possible states of $\mathrm{n_k}$,

$$C_k\Psi_{\mathrm{k}}(r,t) = \phi_k\Psi_k(r,t) \quad \text{and} \quad {C_k}^+\Psi_{\mathrm{k}}(r,t) = {\phi_{\mathrm{k}}}^*\Psi_k(r,t) \qquad (63)$$

These equations point out that the destruction operator has a complex Eigen value of ϕ_{k} which specifies an *order parameter* for the wave functions to become coherent. Similar properties can surely be written for the creation operator. The order parameter ϕ_{k}, the Eigen value of the destruction operator of C_k , is defined as a complex number hence the destruction operator must be a non-Hermitian operator. In this case, the destruction operator average $\langle C_k \rangle$ precisely equals to ϕ_{k},

$$\langle \Psi_k(r,t) | C_k | \Psi_k(r,t) \rangle = \phi_{\mathrm{k}} \qquad (64)$$

The complex order parameter of ϕ_{k} physically determines the phase angle relating the individual wave vectors of $\Psi_{\mathrm{n_k}}(r,t)$. The coherence of the wave functions accompanying all the bosons/Cons is vital to perform and manage consciousness and therefore neuron activities.

The external information basically changes the mean/expected value of the occupation number. Hence the mean occupation number must be related to the joint operation of creation and destruction operators and of course to the order parameters. This relation is very straight forward and can be expressed by,

$$\langle n_k \rangle = \langle \Psi_k(r,t)|n_k|\Psi_k(r,t)\rangle = \langle \Psi_k(r,t)|{C_k}^+ C_k|\Psi_k(r,t)\rangle = \phi_k^* \phi_k \qquad (65)$$

The Cons are assumed to be Bose particles, in contrast to Fermions which occupy any space only one at a time, bosons have the advantage that they can be generated at any space as many as one wants by repeated application of the creation operator on vacuum. Any number of n_k Bosons/Cons can crowd into any single wave function of $\Psi_k(r,t)$.

In order to obtain coherent wave functions suggestive of the coherent mental states just one single wave number of k is assumed. The standard Quantum Field Theory offers that the coherent Glauber states of bosons/cons can be written in terms of the vacuum state wave vector and complex order parameter;

$$\Psi_k(r,t) = \exp(\phi_k {\phi_k}^*)\Psi_0(r,t) \qquad (66)$$

The coherent state is made out of varying number of bosons/Cons and the equation (65) states that the average occupation number is simply equal to the joint operation of the creation and annihilation operators. The coherent state due to the mode k, in the zeroth order, is also given by the exponential form that is,

$$\Psi_k(r,t) = \sum_{n_k=0}^{\infty} \Psi_{n_k}(r,t) = \Psi_0(r,t) + (\phi_k {\phi_k}^*)\Psi_0(r,t) + \frac{(\phi_k {\phi_k}^*)^2}{2!}\Psi_0(r,t) + \cdots$$

(67)

The remarkable aspect of this wave function is the possibility that at any given time, there can be any number of bosons/cons in the wave vector of k and the, ϕ_k are complex order parameters. If we choose these parameters sensibly, then the different probability amplitudes $\phi_k {\phi_k}^*$ of each of the Fock State n_k will add up constructively to give a macroscopic amplitude of bosons/Cons only if they have a common phase angle θ_k: When this happens we get the coherent states of $\Psi_k(r,t)$. The equation (65) actually offers a smart expression for the order parameter, which is,

$$\phi_k = \sqrt{\langle n_k \rangle}\exp(i\theta_k) \qquad (68)$$

Assuming the individual personalities, different functions of $\{\Psi_k(r,t)\}$ must of course be distinguishable. Although the electrical signals/action potential waves traveling through the neurons are all alike to start with, what eventually distinguish them one from the other is the response they provoke in the different sensory channels? The overall coherent state due to all $\{\Psi_k(r,t)\}$ functions can now be determined.

Concerning the global coherent mental wave function, one can write the product wave function, that is

$$\Psi_C = \prod_k \Psi_k(r,t) \qquad (69)$$

This expression, by simply substituting the equation (66), can also be expressed as

$$\Psi_C = \prod_k \exp(\sum_k \phi_k \phi_k^*) \Psi_0(r,t) = exp(\Phi_C \Phi_C^*) \Psi_0(r,t) \quad (70)$$

The coherent mental state Ψ_C has the pleasant property of being able to single out a given function order parameter when it is acted upon by the function field operator, C_k,

$$C_k \Phi_C = \phi_k \Phi_C \quad (71)$$

The global cognitive wave function Ψ_C allows simultaneous measurements in all functional modes k and this is why these operators $\{C_k\}$ commute. We can write for the global order parameter Φ_C

$$\Phi_C^* \Phi_C = \sum_k \Phi_k^* \phi_k = \sum_k \langle n_k \rangle = N_C \quad (72)$$

Here N_C is the global average information population in the cortical brain summed over all the modes. Now, a global cognitive order parameter Φ_C emerges with one single phase angle θ_C to signify over-all phase coherence of the quantum information field. The expression above allows us to write for the global cognitive order in the form of,

$$\Phi_C = \sqrt{N_C} \exp(i\theta_C) \quad (73)$$

In order to obtain the global order, we have summed over all neuron labels. This emphasizes the fact that the cognitive order parameter Φ_C represents in reality the full mental space. The individual label and phase of each neuron has disappeared from the global cognitive order which has emerged with its own global phase θ_C independent of space and time. The global order parameter can be defined as the operator average of the global destruction operator of consciousness C, which is written as

$$\Phi_C = \langle \Psi_C | C | \Psi_C \rangle \quad (74)$$

Now the self-operator has taken a macroscopic significance. The expression suggests the global personality of 'I' and it has emerged as a result of global phase coherence between N_C information bits. The meaning of the global cognitive order is $\Phi_C = I$. This phase coherence is brought about by more and more rapid information transfer through synaptic connections between neurons. A critical neuron bandwidth or connectivity must occur before, I can emerge. The unique global phase angle θ_C, for Φ_C with which order parameter emerges is a symmetry breaking transition. Any other θ would have been equally good from the point of view of total energy of the cognitive system, but this θ_C and only this one, the order parameter Φ_C of the brain system has chosen and retains throughout one's whole life. The expression is named as I; precisely because this unique N_C confers on each individual his individuality, the imprint of a unique personality. The subjective self given by $\langle C \rangle$ breaks the symmetry of the mental space $\{n_k\}$; a subjective-objective symmetry so to speak. From this point onwards, self and self-consciousness emerges as the hallmark of a stable personality.

Mathematically the unique global phase θ_C, translates the fact that the boson/Con population N_C is a variable number and the coherent brain ground state that fixes θ can be expressed in the form

$$\Psi_C(\theta) = \sum_{N_C} \Psi(N_C) \exp(iN_C \theta_C) \quad (75)$$

$$\Delta N_C \Delta \theta_C \sim 1 \quad (76)$$

The uncertainty relationship between phase locking of the global wave function and its information content is fundamental to the coherency of all brain processes.

6.Conclusions

This work has handled the solid problem of mind-matter by philosophically assuming the *Physicalism* along with the approach of *property dualism* which states that the mental properties involving conscious experience can purely be resolved by the physical laws. To start with the human structure is completely analysed by considering the nervous system primarily separating the consciousness from the brain and engaging the ultimate control to the consciousness which is assumed to be appearing as an epiphenomenon of the brain. Specifically speaking the brain-based consciousness is considered to be a dynamic open quantum system continuously influenced by the external sensory information. The external sensory information is assumed to be confined and quantised within the volume of the cortical neurons and interacting with the ordered water molecules and creating the actual Hamiltonian for the consciousness. Effectively the Hamiltonian of the brain-based consciousness is supposed to be due to the electrical and magnetic moments of highly ordered water molecules of the cortical neurons, physically influencing the overall Hamiltonian as the perturbation terms. Therefore, the standard time dependant perturbation theory is assumed to be dominating the dynamical structure of the consciousness and treated accordingly. In this case, any specific sensory information that is expressed by the quantised electromagnetic field is considered to be creating the specific Nambu-Goldstone bosons/Cons. Finally, overall human consciousness and therefore being 'I' is assumed to be emerging by means of those bosons and *standard quantum field theory* is considered to be governing all the processes of the human consciousness, such as thoughts, beliefs, emotions, psychology, personality etc.

The approach presented here is significant in the sense that it solidly connects the environmental information, in other words the living experiences, to the physical brain and further to the abstract concept of consciousness. This means that the built up of the human consciousness and hence the human psychology and personality and therefore individual beliefs and thoughts all strongly depend on the past experiences. This model could surely be beneficial for some practical applications and further improvement on resolving complicated brain functions, psychological issues and anomalies and vital educational problems.

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