Research Report

The archetypal molecular patterns of conscious experience are quantum analogs

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Abstract

We define quantum analogs as vibrational excitations of quasi-particles coupled to electromagnetically-mediated resonance energy transfer in water (a crystal lattice). This paper addresses how neural magnetic resonance spectra of the brain's magnetic field influence dipolar oscillation waves in crystal lattices of interfacial water molecules to produce correlates of phenomenal consciousness. We explore dipolar oscillation waves in hydrophobic protein cavities of aromatic amino acids as a conduit for coherent propagation of vibrational excitation and hydrogen bond distortion associated with phase coherence present in the magnetic field intensity oscillations at a frequency at which the energy switches from its trapped form as excited phonon states to free, cavity-mode magnetic field energy states. A quasi-polaritons that reflect "hydro-ionic waves" is a macroscopic quantum effect of crystal lattice vibrations, consisting of vibron polaritons coupled to ions across the neocortex, except the cerebellum, due to the absence of protein-protein interactions. They are quantum-like at the core and hence can exhibit quantum-like signaling properties when resonant energy is transferred as dipolar waves in hydrophobic protein cavities of aromatic amino acids. This is due to aromatic residue flexibility in molecular electromagnetic resonances. Finally, the archetypal molecular patterning of conscious experiences, which carries an inherent ambiguity necessary for non-contextually applying 'meaning' that encompasses cognitive signatures of conscious experience, satisfies the nature of quantum analogs and their transmutative properties.

Keywords: Electromagnetic resonance; energy transfer; interfacial water molecules; quasi-polariton; conscious experience; hydro-ionic wave; phonons; dipolar oscillations.

1. Introduction

Sir John Eccles [1] was misrepresented as a dualist. He advocated dualist interactionism in the sense of the Self (mind) acting causally on the brain at the quantum level and has wrongly articulated that the mind is non-physical, nonmaterial and nonsubstantial. The electromagnetic (EM) coupling between the quantum and classical domains gives impetus for the interdependence of the two domains. It elaborates on Eccles's radical hypothesis that ultramicroscopic properties are a quantum analog of microproperties of neural communication in the cerebral cortex. The EM force holds atoms and molecules together, thus determining atomic and molecular structure. The EM force is relatively small at the quantum scale, yet it couples with neural activity at the macroscopic scale in a subtle way through EM potentials. The quantum potential is arguably causative in a similar context to the Aharonov & Bohm effect, demonstrating that the magnetic vector potential, rather than the electric and magnetic fields, is the fundamental quantity in hydrodynamic analogs of quantum systems [2]. Therefore, the subtlety of the mind being electromagnetically mediated is at present beyond crude electrophysiological methods of EM probing or neuroimaging by EM reflection and transmission [3].

It is a daunting task to understand brain matter in terms of elementary particles (e.g., matter particles like fermions or bosons), so in quantum biology, physical processes are described as energy transfer or energy transduction. Hagan & Hirafuji [4] consider a "psycho-physical" bridge between interfacial water's molecular dipoles and differing condensates in the *quantum realm* and the resultant transfer of information between the *classical and quantum domains* based on a *polariton model*. They assume that energy transfer is *bidirectional*: quantum signals influence neural function, and neural information can translate into quantum dendritic encoding [5]. The *polaritonic approach* in terms of molecular EM resonances through the evolution of their statistical states carries an inherent ambiguity necessary for non-contextually applying 'meaning' to higher processes. Still, it lacks the dynamical description necessary for linking to neural processing.

The main question arising in the 'two-brains' hypothesis [6] is the origin of the endogenous EM field at the molecular level. More importantly, whether the magnetic field component generated by the endogenous EM field can be used as information has triggered enormous attention recently [7, 8]. At the quantum scale, EM fields are carried by subatomic particles or sub-particles, which are force particles referred to as gauge bosons. Fermions (e.g., quarks, leptons), on the other hand, are matter particles, and the electron is one such elementary particle that makes interatomic bonding and chemical reactions and hence life possible. The most familiar gauge boson is the photon, which is the energy quantum of the EM field. Gauge bosons of electromagnetism are force particles that carry energy and momentum and, in the brain, also convey information. An endogenous EM field's emission of energy quanta causes energy absorption in quasiparticles and vice versa. These force particles scatter the energy, but they are not energy quanta particles but quasiparticles resulting from their interaction with matter particles (e.g., electrons).

Quasi-particles convey a simpler way to represent many brain matter particle interactions than directly describing every real particle. Quasi-particles are bonded states between a carrier and an empty state, which does not mean that the mind is non-physical and immaterial. The bonded pair could transport together, or a pair of a pure empty state could transport through a synaptic cleft as first proposed in [9]. Quasi-particles do not require conducting transport channels; semiconducting or insulator matrices provide a better transmission route. It is also unnecessary to have defects in the ordered structure; quasi-particles could generate and flow through the random lattice sites through topological pathways, as we see statistically in most biomaterials.

Two-brains *hypothesis* [6,10,11] is one way of resolving how energy can transfer from quantum-to-quantum analog states. It claims that: (1) the electro-ionic brain is the domain of cognition, i.e., the ability to process information in terms of neural activity associated with cognitive neuro-computation. It is tangible, known and accessible, recognizable through the third-person perspective and referred to as the "electro-ionic brain."

Electro-ionic pathways are those where ionic flows dominate (e.g., ion-dipole interactions, ionic current flow in axons, large dendritic shafts, and extra synapses), and (2) the EM brain is the domain of subtle energy transfer where a quantized EM field is interacting with dipolar molecules in the very thin neuronal dendrites and protein-protein interactions across the neocortex, except for the cerebellum due to absence of transcription factors for gene expression of protein-protein interactions [12].

There is a basic difference between an electric field and a magnetic field interacting with a biomaterial. The magnetic field tends to transmit in a spatiotemporal loop. Therefore, to understand how magnetic fields arise in the brain, we must first pinpoint that quasi-electrostatic fields are time-varying. However, the electric and magnetic fields may still be decoupled, even though the fields have a time-dependent variation. Due to the generalized Ampere's law accounting for a displacement field, a time-varying electric field in a biomaterial will give rise to a time-varying magnetic field and *vice versa* (due to Faraday's law) over a space in the biological organ [13]. The spatiotemporal magnetic fields flowing in a loop are similar to quasi-particles. The transmission in a loop could act as a clock analogous to biological rhythm, and several such loops generate interconnected clocks that have final phase relationships [14, 15]. Several efforts have been made to map these EM clock assemblies as an architecture of clocks [14, 16]. One of the prime advantages of mapping only the periodic events or transmissions in a loop is that irrespective of the carrier, electron, ion, photon or quasi-particle, the 3D assembly of clocks includes all of them in the varying time domain [17].

Due to the brain's magnetic field intensity generated by spontaneous currents, the magnetic field energy is very low, below thermal noise energies. Hence it cannot be expected to affect neural processes. This contrasts with the conscious EM information field (CEMI) theory, which claims that information within neurons is pooled and integrated to form a conscious EM field [18]. CEMI theory requires the synchronous firing of large numbers of synapses on cortical pyramidal cells that oscillate at certain frequencies, thereby perturbing a global EM magnetic field external to them, creating a "pattern" representing neuronal information feedback to the neurons as 'consciousness' [19]. This feedback is regarded as modifying the electric charge across membranes affecting how neurons fire.

Given that the strength of the extracellular EM field is local, a spatial EM field pattern may generate a link leading to global periodic oscillations, potentially encoding any given cognitive experience provided resonance frequencies are involved [8, 17]. The geometric profile in the global frequency space would be undetectable at a short distance from where it was generated. This, in turn, means that neurons across the whole brain would not be "turned on" by these localized, putatively conscious EM patterns [20]. The triplet of triplet EM resonance pattern in the distribution of resonance frequencies is one example of a long-range order [8]. Therefore, it is the endogenous EM field at the molecular level and not a self-propagating 'conscious' exogenous EM field which governs the emission and absorption of energy quanta sensitive to magnetic instabilities [21].

In the brain, the endogenous EM field at the molecular level is considered minuscule yet not completely absent, i.e., when quasi-electrostatic conditions prevail [22]. Thus, minuscule can mean 'subtle' but not negligible. Its presence is caused by an intrinsic property of charged particles endowed with "*spin*", a quantum of magnetization. It can affect other magnetic dipole moments [23] due to magnetic dipole-dipole interactions (via the Heisenberg term in the Hamiltonian), explaining their sensitivity to the quantum phase shifts. The system phase is changed by the magnetic vector potential [24]. The phase of every coherent system becomes a 'memory' of the events occurring across the whole relation [25]. This is possibly how the discrete conscious (vector) field becomes a unified field through phase correlations between dipolar molecules without classical transportation of information. Such phase correlations are called resonances coupled to dipole oscillations which are coherent molecular patterns that may induce a '*biological order*' (see [26] for a review). Nonlocally induced molecular quantum dynamic effects are subtle, not governed by a self-force associated with individual electrons carried by a quantum force [27], but quantum-mechanically on densities of quasi-free electron states, influenced by the endogenous EM field at the molecular level.

Most, if not all, of the experimental data in modern neuroscience, are based on tissue/brain extracellular EM fields driven by ionic variability [8,28,29]. Yet, there is no *in vivo* experimental evidence to indicate a viable endogenous EM field at the molecular level. How can the two-brain hypothesis be tested? Electromagnetic fields are generated by the net effect of electrolytic current flows [30] and EM dipole oscillations. Still, they exclude the effects of bound charges within the microstructure [31]. EM waves in hydrophobic protein cavities [32] and mitochondria [33] represent EM resonances. They are the origin of the endogenous EM field in aromatic studies of amino acids and organelles. Hales [34] has applied classical electromagnetism in free space through Maxwell's equations to describe the endogenous EM field. Still, this is inappropriate as EM waves in hydrophobic protein cavities provide a more accurate description, i.e., cavity electrodynamics.

2. Vibrational motion in crystal lattices of interfacial water molecules

The major forces between dipole molecules are EM. Such forces can result in EM dipolar oscillations. The quantized endogenous EM field can invoke molecular dipole oscillations. The neuronal branchlets contain an abundance of molecular dipoles encased within the microstructure [31], producing EM dipole oscillations to ensure strong coupling between photons in given crystal or molecular wavebands. However, this quantum interference effect does not require a strong magnetic field to exist endogenously because it is not the intensity of the magnetic field but the interference pattern shifts that describe the rhythm of oscillations of the field expressed in terms of periodicities of discrete energies [24].

All binding forces between atoms and molecules are electromagnetic, and as a consequence, all chemical reactions are electromagnetic processes. In particular, the release of photons from chemical reactions during metabolic activity plays a fundamental role in electromagnetic couplings to proteins and macromolecular structures. These electromagnetic quantum interactions produce dynamic order in far from thermodynamic equilibrium systems. Global order emerges in the collective mode of the emission and absorption of energy quanta (photons). Due to the presence of this global order, the emission and absorption dynamics produce a macroscopic effect resulting in a collective excitation that propagates causality upscale to the molecular level, so quantum properties of interfacial water have a pivotal role in protecting from decoherence and allowing for periodicities of discrete energies of collective excitations to serve as a messenger of biological causation.

Interfacial water enables causation to be carried in neuronal branchlets at relevant frequencies of the coherent domains (approximately 0.1 μm in diameter that includes millions of dipolar molecules), fertile ground for energy transfer and long-lasting excitation [35]. The characteristic frequency of the coherent domains is based on the concept of frequency changes when energy is stored in a coherent domain [36]. If other dipolar molecules oscillate at the boundary with the same frequency, they will become part of the coherent domain and propagate information across the brain. In this way, harnessing stored energy of the coherent domain and transporting intrinsic quantum fluctuations across the brain as periodicities of discrete energy quanta is a viable hypothesis, which is equivalent to the Fröhlich effect that energy provided may not be completely thermalized but redistributed towards lower frequency modes of vibration.

As a complex adaptive system, the brain is composed of smaller parts interacting both within and across scale as a non-reductive physical system that is far from equilibrium. In this open system, the entropy decreases with increasing molecular order (i.e., high degree of coherence), leading to self-organization phenomena to store more information. Interfacial water does not store intrinsic information, but it acts as a conduit for the endogenous EM field through which the brain can readily communicate information. For example, interfacial water contains a narrow zone of protons, as positively charged hydrogen ions rapidly move from one water molecule to the next. The principle of protonic conduction in water using the Grotthuss mechanism [37] can transfer quantum and quantized information through proton nuclear spin ensembles in polarized proteins.

All catalyzed reactions result from conformational changes via mechanisms similar to protein folding. In particular, the release of photons as by-products resulting from free radical recombination reactions can be significant [38-40]. The dipolar waves between dipolar molecules in proteins are sensitive to endogenous EM fields and are sourced by metabolic energy. The quantized dipolar waves emerge from dipole-dipole interactions and dipolar molecules' interactions in the ice-like hexagonal lattice structure of interfacial water [41] (i.e., decomposed into vibrations with conformational states and conformational transitions). This traveling conformational wave from which weak photon emission [42,43] strongly couples to conformation waves is sensitive to the endogenous EM field, resulting in vibrational excitations.

Vibrational excitation propagates to neighboring dipolar molecules due to dipole-dipole interactions. The excitation interacts with the hydrogen bonds of interfacial molecules, creating a local deformation coupled to the vibrational excitation. A new non-dissipative state associated with vibrational excitation and hydrogen bond distortion will propagate coherently if the coupling is sufficiently strong. This mode of vibrational energy transfer is known as conformational transitions in the crystal lattice structure of interfacial water molecules subjacent to endogenous microstructure.

Still, they can also occur across polarized crystal lattices of water molecules where electrons and hydrophilic protein cavities occupy adjacent molecules [44]. Dipole moment coupling to conformational states in interfacial water dipolar molecules and molecular conformational transitions was first postulated by Fröhlich [45]. Coherence is associated with Bose-Einstein type condensation not of material particles but rather of energy quanta consisting of quasi-particles as collective modes (motions) of vibrational excitations (see also [46]).

Resonant energy transfer in macromolecular systems is called dipolar waves (conformational waves)–an excitation can transport energy without transporting net electric charge, representing a transient switch in the dipole moment (charge separation). The propagation of such dipolar waves can induce a polarization density of interfacial water dipoles, causing a breakdown of the dipole rotational symmetry. This affects the conformational states in dipolar molecules. Photons can induce conformational transitions between vibrational energy levels. When a molecule enters a higher energy vibrational level, it will drop to a lower level and emit a photon whose energy corresponds to the energy difference between these two vibrational levels. The dynamics of molecules can be decomposed into vibrations within particular conformational states and conformational transitions. Therefore, coupling to conformational transitions (via a mechanism similar to protein folding) in crystal lattices of interfacial water molecules where disordered energy (e.g., metabolic) is transformed into dipolar oscillation waves by resonant energy transfer. Such dipolar waves propagate across the crystal lattices of interfacial water molecules. Dipolar waves come about from dipole-dipole and their interaction with quantum modes of vibration, i.e., phonon-polaritonic vibrations. These result in the coherent order of energy quanta induced by EM dipolar oscillation waves in and around the endogenous microstructure of neurons (see [47] for a review).

Dipolar molecules are arranged to give an array of dipoles: linear electric dipolar chains corresponding to a long chain of proteins. Because of their electric charge separation, polar molecules can interact with water without disrupting the ubiquitous lattice of hydrogen bonds that the water molecules naturally form. Interaction between groups of charges of the dipoles in a macromolecule manifest in vibrational motion with a characteristic frequency. Each dipole interacts with other dipoles via intermolecular forces, e.g., dispersion forces; the result of these interactions causes the dipole oscillations to spread with a certain frequency into a narrow range and provide energy transfer between dipoles. Thus, the collective mode of vibrational excitations involving the myriad of protein molecules within neurons, including the extracellular matrices of the brain, represents a collective wave of dipole oscillations.

At the microscopic scale, the EM brain dominates [48]. Quantized EM field supported by the interfacial water molecules forms magnetic dipole oscillations coupled to vibrational excitations around endogenous nanostructures within distal, very thin neuronal branchlets. The interaction between vibron polaritons and dipolar waves across crystal lattices of interfacial water molecules results in quasi-polaritonic waves, which are dressed polaritonic waves. These polaritons can form a Bose-Einstein condensate of the Fröhlich-type because their energy is pumped (activated) through chemiosmosis. The presence of quasi-phonons, which consist of modulated EM field energy, is supplied through protonic conduction. Unlike fluids with pseudo-plastic properties and a viscosity similar to an axoplasmic fluid, the crystal lattices of interfacial water molecules surrounding cavities of endogenous microstructure exhibit, through the *Grotthuss mechanism*—the hopping of hydrogen ions (protons). The protonic conduction is supported by the interaction with vibron polaritons, which in the presence of an EM field at the molecular level can lead to super-fluid like-dynamics, which is the capacity of quantum fluid to move without dissipation [49]. The vibron polaritons and dipolar waves couple to form quasi-polaritons.

The functional role of crystal lattices of interfacial water molecules was shown to act as a conduit where energy is transferred like a dipolar wave [50]. The frequencies of dipolar fields are comparable to the coherent order of interfacial water dipolar molecules. This allows the dipolar wave to propagate between the interfacial water dipolar molecules, referred to as '*water lasing*' [51].

Georgiev & Glazebrook [52] estimated that water lasing within an ionized milieu of ordered water is attained for 10^{-11} sec, during which quantized excitation polarization wave up to 25 nm in size acts causally throughout the EM brain [53]. In the absence of coherent ordering of dipolar water molecules, protein molecular dipoles in neurons possess a decoherence timescale under 10^{-13} sec [54]. Craddock and his colleagues [55] claim that quantum states are sufficiently shielded by ordered water in microtubules to prevent thermal decoherence. However, this may occur not just in the microtubules but also throughout non-polar regions in cells [56,57].

Interfacial water's crystal lattice structure acts as a transfer medium for endogenous EM waves to dipolar molecules resulting in conformational waves (dipolar waves =quantized polarization waves in interfacial water crystal lattices). Conformational changes occurring in nanoseconds and more are triggered by charge redistribution, which may be caused by EM dipole oscillation within regions of dipolar molecules [45]. The flow of protons, i.e., positively charged hydrogen ions, across the mitochondrial membrane gives the metabolic enzymes energy to produce ATP molecules (biological energy quanta) through chemiosmosis. Such external feeding of energy through the ATP molecule reaction may trigger the formation of macroscale quantum-like solitons in interfacial water [50,58] when coupled with photons [40] to generate quasi-phonon transport through

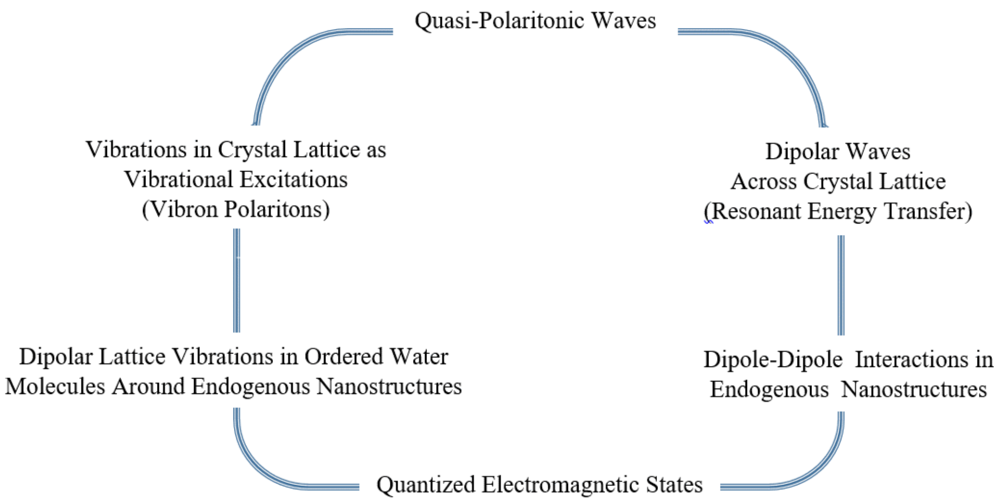

Fig. 1 *The electromagnetically-mediated wavelike vibrational excitations coupled to dipolar waves through interfacial water crystal lattices produce quasi-polaritonic waves in the most neocortical milieu. When the bulk of the vibrational excitations occupy the ground state and become a single macroscopic state characterized by a subtle macroscopic quantum effect, this manifests itself as **quasi-polaritonic waves** consisting of vibron-polaritons coupling with resonant energy transfer.*

a dynamically ordered region of water surrounding a dipolar molecule up to the coherence length < 50 microns, which would cover most of the cell's interior [59]. These sizes require the corresponding frequencies of acoustic waves to be in the range from 100 MHz to 1 GHz, while EM waves would have the corresponding frequencies in the 1-10 THz range [60, 61].

Wu & Austin [62] proposed a model Hamiltonian to describe the interaction of the quantized EM field with dipolar molecules to yield a coherent *Fröhlich-style Bose-Einstein condensate,* with condensate not of material particles rather of energy quanta of excited collective polar modes of vibration (see also [46]). Rapid polymerization of tubulin proteins (10^6 times faster than normal rate) into a microtubule nanowire was shown by pumping tubulin proteins with EM energy at resonance frequencies using an antenna [7]. However, the Bose-Einstein condensate would be unstable in the brain's noisy, warm and wet medium.

Furthermore, neurons may have even deeper-level quantum information-processing channels, namely microtubular lumen spaces that are almost certain to contain interfacial water [63]. The lumens of microtubules are shielded from the cytoplasmic environment by a 5 nm wall of tubulin and an electrostatic potential gradient of approximately 100 mV. The inner diameter of microtubules is approximately 15 nm, well below the 100 nm limit of interfacial water coherence domains at ordinary temperature and pressure [64,65], which indicates that interfacial water can undergo an anti-ferroelectric-ferroelectric *phase transitions* leading to the emergence of an ordered, coherent state in such nanopores [66]. Hence vibrational excitations can be generated, sustained and processed in these confined spaces [7]. Moreover, they can be coupled to subtle EM signals, especially those that propagate longitudinally since neuronal branchlets are open to the external environment. There may be additional means of controlling these macroscale quantum states by electro-ionic flows through the nanotube-like openings. This also allows for a unified model of classical/quantum interactions inside neurons via a well-developed model of ferroelectric properties of nanostructure involving the dipolar degrees of their building blocks, tubulin dimers [67].

3. How energy switches from one energy state to another

In far from equilibrium open systems like the brain, the entropy decreases with increasing '*biologic order*' (i.e., high degree of coherence), leading to stability. It is understood that self-organization is a process by which biological systems spontaneously develop a '*biological order*' at a higher level [68]. Del Giudice and his colleagues [50] advocated quantum properties of interfacial water, but no specific mechanism was proposed. Some have argued that the preferred EM frequencies can be found in the range corresponding to intrinsic quantum fluctuations. Their mutual coherence of resonances may explain the emergence of Bose-Einstein condensates at room temperature to stabilize '*biological order*' [69].

How does the *polariton wave* cause stability? It is postulated that polaritons create self-organization due to *Bose-Einstein condensation-like induced stability* [45]. The *Bose-Einstein condensation* strongly couples biophotons with the molecular structure, so the system self-organizes into a stable state. Numerous studies point to '*dipolar order*' at the macroscopic scale via hydrogen bonds (see, e.g., [51,52,70]). At a macroscopic scale, the processes of protein folding as conformational transitions are coherent excitations resulting from the structural coherence of molecular dipoles in a common voltage gradient (under quasi-electrostatic conditions) termed *Bose-Einstein condensation-like excitations* [45,71,72]. Coherence requires molecular quantum mechanics, but only exceptionally stable quantum states avoid decoherence at room temperature. The *Bose-Einstein* condensate is such a state, but it persists at room temperature if induced by the polariton formation in submicron neuronal branchlets [73].

The polaritonic model requires that the quantum state of the brain has a property called *macroscopic quantum coherence***,** which needs to be maintained for around a few milliseconds. Still, according to [54], this property does not hold for more than 10^{-13}s. Hagen and colleagues [74] have advanced reasons why this number should be up to a few milliseconds, but this is a very big difference to explain away, and serious doubts remain about whether quantum states can exist in the brain. The resolution comes in the stability from *polaritonic waves* that emulate the quantum brain states in the brain. At the molecular level, endogenous microstructures connected in a common voltage gradient field and within a very thin neuronal branchlet would oscillate coherently at nanosecond periodicity if energy were supplied from adenosine triphosphate (ATP), for example. Unfortunately, quantum behavior asymptotically turns into classical behavior in macrosystems at room temperature due to decoherence. Polaritons are the exception [75, 76].

In the absence of polaritons, the decay of the vibration occurs at under 10^{-13} sec [54]; much too quickly before they can be stabilized by Bose-Einstein condensation, but not so by replacing the vibrations by vibron-polaritons. The problem with decoherence remains unless there is no interaction between the nucleus of atoms in molecules and the endogenous EM field at the molecular level. Thus, can the polaritons be protected from EM influences by coherent ordering in the crystal lattices of water molecules? The nteractions in the crystal lattices of interfacial water identify the brain as quantum-like at the molecular level [77]. The crystal lattice structure of interfacial water keeps the entropy low, and the characteristic stability of quantum-like coherent states ensues [66, 78].

This significantly increases the lifetime of polaritons in such crystal lattices, with periods on the picosecond timescale giving them a far from quasi-equilibrium nature (evanescent) but constantly updated from energy transport in discrete crystal lattices to generate continuous charge transfer in molecules by attachment to ions governed by nanosecond timescale and the emergence of dipolar oscillation waves in microstructure [79].

Phonons are quantized lattice vibrations stemming from the crystal lattice structure of interfacial water. They are collective excitations responsible for generating and maintaining dipolar order and can involve the collective modes of oscillating dipolar fields and localized dipole moments throughout the brain. In particular, the phase difference in dipolar oscillation waves governs dipolar order. Macromolecular assemblies contain dipolar molecules that give rise to an ordered array of molecular dipoles, and EM dipole oscillations occur when the dipole order propagates as one traveling condensate. The interaction between molecular dipoles within ordered water manifests in a collective vibrational excitation by transforming any incoherent or disordered quanta of energy into a distinct collective mode of excitations and the myriad of dipolar molecules [50,80]. Vibrational excitations propagate to neighboring dipolar molecules due to dipole-dipole interactions. Interaction between groups of charges of the molecular dipoles in macromolecules manifests in vibronic oscillatory motion with a specific frequency. Each molecular dipole interacts with other molecular dipoles via intermolecular forces, e.g., dispersion forces; these interactions cause dipolar oscillation waves to spread with frequency into a narrow range and provide energy exchange between molecular dipoles.

Energy switches from its trapped form as excited photon states to free, cavity-mode EM field energy states due to *self-organized quantum criticality* at the molecular level. According to Mandell and his colleagues [81], it arises from the generation of intermittent turbulent magnetic fields from complicated interactions in the magnetic fields themselves. Dipolar oscillation waves at critical instabilities possess very high coherence lengths, keeping them so integrated that their dynamics cannot be reduced to component excitations; they are non-reductive [82]. The idea is based on self-organized quantum criticality emerging due to magnetic instabilities that arise from magnetic gradient force (cf. [21,83]), potentially resulting in energy transfer to stabilize the polaritonic waves in very thin, distally isolated branchlets.

Our hypothesis is that magnetic instability arises from the motion of charge redistribution that may induce local magnetic forces; and the intrinsic magnetism of electrons. Electrons have intrinsic magnetic moments relating to the intrinsic angular momentum ‘spin’, which is quantized, and the smallest unit of spin magnetization is called the Bohr magneton. These intrinsic magnetic moments give rise to the macroscopic effects of magnetism arising in the EM brain under quasi-electrostatic conditions. The spin projection creates *polaritonic waves* to self-organize into a stable state. The spin projection of up dot up or down dot down is observed and recognized. These are the parallel components that can increase the magnetic force and self-organize. Moreover, oscillating magnetic fields (due to their instabilities) can alter the release of photons through reactive oxygen species [84], suggesting that the polaritonic waves serves for energy storage and stable channeling of EM energies.

6. Resonant energy transfer mode coupled to mode of vibrational excitations

Hydro-ionic waves are quasi-polaritons coupled with lattice vibrational motions that can, in theory, exist due to ionic dipole interactions in very thin neuronal branchlets within the electro-ionic brain. The nonlinear effect of strong coupling between quasi-polaritons and quasi-phonons results in a modulated EM field energy in cavity modes the so-called “*hydro-ionic wave*” (see [85]). The hydro-ionic wave has a subneuronal origin consisting of polaritonic waves in the endogenous EM field. Polaritonic waves carry away the quasi-free electrons kinetic energy[1], giving rise to quasi-polaritons upon reaching the electro-ionic brain (see **Fig. 2**). In the electro-ionic brain, the quasi-polaritons attach to ions and interfacial water molecules, propagating as a

[1] Quasi-free electrons interact in the crystal lattices with vibron-polaritons that carry away their kinetic energy.

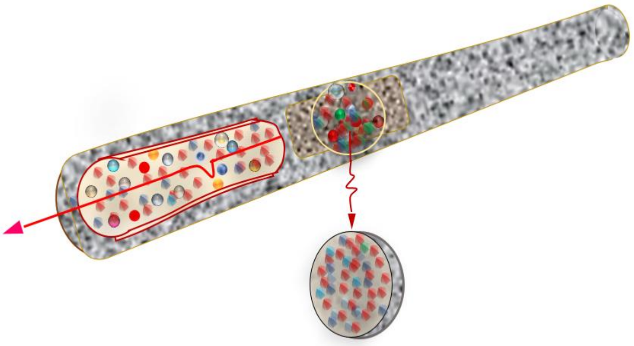

Fig 2. *Schematic diagram illustrating a terminal cortical interneuron branchlet containing dipolar molecules in an endogenous EM field where molecular dipoles (not to size) are arranged orderly and surrounded by the charged milieu of interfacial water. The quantized polarization-induced behavior of dipolar molecules leads to a hydro-ionic wave (red arrow). Hydro-ionic waves are macroscale quasi-polaritons transporting energy from the EM brain to the electro-ionic brain. It is an EM wave arising in the microstructure of the neuronal branchlet with a uniform diameter of under 100 nm in diameter and about 0.7μm in length. The hydro-ionic wave originates in the EM brain from constituents of quasi-polaritons propagating at speed (v) much slower than the velocity of light (c) (i.e., v << c). The size of the polariton as a quasi-particle wave is at most 25nm [53]. Still, the quasi-polariton is much larger within the limits of coherent domains of interfacial water (100nm) and the approximate size of very thin neuronal branchlets. The mid-region shows a greater propensity of dipolar molecules, as shown in the inset for illustrative purposes resulting in movement of charge redistribution.*

hydro-ionic wave to higher levels of awareness. The hypothesis states that the polaritons relate to the unconscious and conscious states. The polaritons oscillate between the excitation of a material system, which is the unconscious encoding part of the polariton. The quantized EM field is the conscious decoding part of the polariton.

The polariton wave is confined to the endogenous microstructure of the neuronal branchlet, which is why polaritons can form quasi-polaritons. It is postulated that the coherent part in the *quantum-like realm* carries subjective 'meaning' that modifies the *classical realm* as the functional part. In other words, the 'hydro-ionic' wave may plausibly be a vehicle for the transmutation of quantum-level magnetic fluctuations to normal-level neural signaling. It is hypothesized that 'hydro-ionic' waves influence unconscious cognitive processes, and their interaction governs the subtle EM energy transfer into a conscious state. The transfer of energy from polaritons to quasi-polaritons involves ion-dipole interactions.

EM energy transfer dynamics, coupling between phonons and photons, with kinetic energy 10^{-5} times smaller than thermal noise in neurons [73]. To resist thermal noise, polaritons attract the additional mass of interfacial water molecules and build their kinetic energy by propagating in a crystal lattice of vibron-polaritons. Therefore, quasi-polaritons become the result of ion-dipole interactions. In the classical realm, the quasi-polaritons and quasi-phonons from which protonic currents result (i.e., proton motion tied to hydrogen bonds) have the unique property of dipolar order, which resists degeneration by thermal noise, and which gives rise to such vibrations. The emergence of quasi-polaritons results when polaritonic waves attach to ions and interfacial water molecules in neuronal branchlets. It should be emphasized that there is no electro-diffusion of ions or ionic variability since the ion-dipolar interaction involves a fixed ion attaching to the polaritons, becoming quasi-polaritons in which charge gets transported.

Electromagnetically-mediated dipole oscillations constitute vibrational excitations resulting from patterns of quasiparticles. This is postulated to occur by energy transfer between proteins, which are quasiparticle patterns depicted as dipolar waves where polarized proteins within the ionized milieu of interfacial water form a collective wave of dipole oscillations. Indeed, the disruptive role of thermal collision is neutralized, and the whole interfacial water is allowed to stay coherent [86]. The distances are only a few nanometers, but when instantiated by electromagnetically-mediated interactions, the collective modes of vibrational excitations in dipolar molecules across many neurons are possible and may be produced from biochemical energy.

Subsequent decay of dipolar waves propagating through a medium such as the intracellular space of neurons transfers energy via protein-protein interactions to induce conformational changes resulting from chemical (hydrogen) bond breakage, causing energy transitions leading to an ultra-weak non-thermal spontaneous emission of photons. In the presence of an EM field, polar protein molecules can undergo coherent conformational changes and couple to collective waves of dipole oscillations depicting collective modes of vibrational excitations. The dipole order propagates as one traveling weak polaritonic condensate to form quasi-polaritonic waves. In quantum mechanics, one cannot directly measure an action but only the evolution of the statistical states. However, in hydrodynamic quantum analogs like the quasi-polariton, there is a dynamic description of quasiparticle patterns that transform any incoherent or disordered quanta energy.

7. Magnetic clock or vortices in the simulated brain model

Brain magnetic field intensity due to spontaneous currents is less than thermal noise energies and cannot affect the brain's processes. However, this quantum interference effect does not require a strong magnetic field to exist endogenously because it is not the intensity of the magnetic field but the interference pattern shifts that describe the rhythm of electric oscillations expressed in terms of periodicities of discrete energies[2]. Therefore, the negligibility of a magnetic field in the brain likely remains immaterial for a coherent domain of excitations. Poznanski and colleagues [24] suggested that it is not the intensity of the magnetic field but the interference pattern shifts that describe the rhythm of oscillations of the field. One of the key parameters for such oscillations is expressed in periodicities of discrete energies. This theoretical argument forms the basis of the quasi-polariton model, where the flow of magnetic flux in a loop could itself be a quasi-particle.

Using elementary geometric structures made of dielectric materials, a replica of the brain organ in the computer simulator was created by solving Maxwell's equations. Its reflection (S11) and transmission (S12) coefficients were determined as a function of frequency. The frequencies that deliver peak values of coefficients are resonance frequencies. At the resonance frequencies, electric and magnetic field distributions were obtained for the surface of the biomaterial. Here the biomaterial is the connectome neural fiber network. It is the largest component in the brain (**Fig. 3a**; [87]). Simulation of this structure shows that the magnetic fields in the brain exhibit different patterns depending on the brain resonance frequencies (**Figs 3b, c**). The

[2]Energy scales in physics decrease as length scales increase because of the quantum relation:

$$\ell = hc / E,$$

where ℓ is the length scale, E=hf is the energy scale in units of Planck's constant, f is the frequency or periodicity of discrete energies, and h is the Planck's constant. . A useful approximate value is hc = 1240 (MeVfm) = 1.986 × 10−25 (Jm).

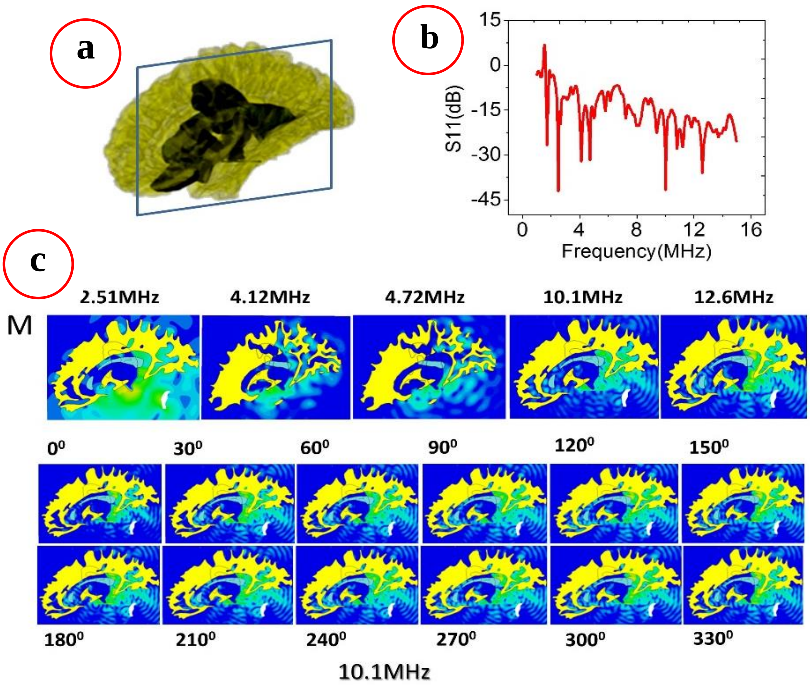

Fig 3: *Magnetic field profile at EM resonance for the brain model is depicted here.* ***a****. In the brain architecture, the black highlighted part represents the mid-brain region.* ***b****. We simulated the brain model by stimulating the mid-brain through a waveguide port. The resonance band is observed in the MHz range with 2.51,4.12,4.72,10.1 and 12.6MHz resonance frequencies.* ***c****.* ***Top panel****: The magnetic field distribution is detected at all resonance frequencies in the brain regions. The magnetic field is concentrated near the waveguide port at 2.51 MHz resonance frequencies, while at 4.12 and 4.72 MHz frequencies, the magnetic field dominates in the cerebellum region. Magnetic energy is confined to the lower brain structure at the 12.6MHz frequency.* ***Bottom panel****: The magnetic field flow like a spatiotemporal clock in the brain is shown for a complete phase cycle (0^0–360^0) at a 10.1 MHz frequency. The magnetic field is confined to the corpus callosum during the initial phase. During the phase cycle, gradually, the field appears beyond this region and moves to the cortex region. The magnetic field is again focused on the corpus column during the half-phase cycle. The nature of the magnetic field distribution is repeated for the next half-phase cycle (180^o).* ***Simulation details****: Used software- CST, computer simulation software; solver- time domain; simulation frequency range- 0-16MHz; boundary condition- open space; waveguide port dimension- 40mm x 40mm.*

brain was stimulated by placing an energy source in the lower part of the midbrain, replicating the rapid brain response process. The transmitted and refracted waveforms were constructed, and solutions to corresponding Maxwell's equations were made to find coefficients of wave functions in the computer simulation technology software, CST. The *magnetic clock*-like loop of magnetic flux flow appears at each resonant frequency; we only presented the 10.1MHz resonance peaks. The magnetic energy intensity peaks transmit through a loop periodically over one complete phase cycle (0^0–360^0) (see **Fig. 3c** lower panel). The magnetic field dominates more than the electric field at all frequency scales in the brain. It is the most important finding supporting Poznanski's [24] proposal for the magnetic field in the brain. A previous study already reported the clock-like flow of the EM wave for the microtubule, axon, and tubulin [87]. A recent study suggested that magnetic excitations or magnons could transmit information more reliably than electrical conductors. The flow of electric currents generates heat due to electrical resistance, but magnon-like magnetic quasi-particles can transfer information without heat loss [88].

7. Conclusions

It seems reasonable to hypothesize that the archetypal pattern of conscious experience depends upon distinct brain mechanisms. This paper has outlined a mechanism that proposes that proteins utilize magnetic quasi-particles. Certain molecular interactions are responsible for energy transfer that could underlie dipolar oscillations at critical instabilities as the missing ingredient of the molecular consciousness [89]. The uniqueness of the neuronal branchlets is that they are isolated from diffusive ionic motion, which could, in principle, eliminate a cavity polariton from existence. Unlike microtubules found in other body organs, e.g., the liver, the neuronal branchlets are uniquely positioned, contiguous to thick neuronal arbors that ignite cognitive neurodynamical processing through electro-diffusion of ions and action potential conduction (cf. [90]).

Quantum mechanics may relate to dualistic consciousness, but our work was based on a hydrodynamic quantum analog description of magnetic loop fluctuations in the EM brain as the phase coherence in the charge redistribution of the dipolar oscillations. *The quantized polarization waves* that emerged from the functional capabilities of interfacial water molecules involve charge densities and hydrogen bonds in an EM field, in which ordered water within microstructure is coupled to vibrational excitations and photons, resulting in vibron polaritons (polaritonic waves). The *polaritonic waves* affect the momentum of charge redistribution in interfacial water that surrounds the microstructure in neuronal branchlets and serves as a conduit for transferring energy to the electro-ionic brain. Such resonance energy transfer coupled to vibron-polaritons defines a quasi-polariton. This is, in essence, a quasi-polaritonic wave. Its quasi-particle core is dependent on the neuropil's material composition. The material composition of brain consciousness consists of quantum analogs, i.e., quasi-particles in amino acids coupled to EM mediated resonance energy transfer in water (as crystal lattice). In future work, we will show how quantum analogs and their transmutative properties enable consciousness to be expressed in cognition as conscious experience.

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Conflict of Interest

The authors declare that they have no conflict of interest

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