



Original Research

Consciousness: a quantum optical effect in fluorescent protein pathways

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DOI: <https://doi.org/10.56280/1648335153>



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Received 6 August 2024

Accepted 9 September 2024

Online published 16 September 2024

Abstract

This paper presents a physical mechanism of embodied consciousness based on the dynamic organicity theory. We use the entropic pilot wave theory to describe the quantum dipole oscillations from dipole-bound delocalized (quasi-free) electrons in nonpolar nanocavities of aromatic amino acid residues (benzene moiety /cyclic hydrocarbons that contain resonance structures) and their fluorescent pathways. These pathways contain cavity quasipolariton condensates composed of quantized polarization waves of entangled photons. The behavior of oscillating molecular dipoles is influenced by the quantum nature of dynamic organicity, which causes energy fluctuations necessary to move delocalized electrons and create bare polaritons (quantized polarization waves). These waves correspond to photon quasiparticles interacting with water molecules to form quasipolaritons, softened by interacting with hydroxide ions (OH^-) within crystal lattices of interfacial water H_3O . When $[\text{H}_3\text{O}^+]=[\text{OH}^-]$, the solution is neutral in hydrophobic nanocavities. In such nonpolar cavities, evanescent photons (non-radiative transitions in the absence of any source) are emitted while protons (H^+) diffuse due to recombination with hydroxide (OH^-) ions, acting as protonic analogs of 'holes' or excitons. In protein pores, proton motion strongly coupled with π -electron delocalization is a conduit for exciton-photon (polariton) and its polarization wave component. Internal energy fluctuations comprise both quantum potential energy and negative quantum kinetic energy. We explore how quantum potential energy influences the negentropic effect of a 'repulsive force' guided by entropic pilot waves through pilot wave force (negentropic force), functioning as an information-based action of the polarization wave as a conduit of the cavity quasipolariton. When the rate of change of quantum entropy is zero, and momentum of the polarization wave is zero the internal energy transduction between quantum potential energy to quantum kinetic energy manifests as the negentropic force and facilitates the movement of information-based action for information encoding when negative quantum kinetic energy happens at certain times. Experiments have shown that biphoton entanglement interferes with anaesthetics. We postulate that the disruption of cavity polaritonic condensate through its polarization wave component disrupts the decoding of information, suggesting consciousness is attributed to a quantum optical effect. Therefore, we further theorize that consciousness is attributed to the negative quantum kinetic energy of the polarization wave, which provides an informational structure of multiscale redundancy when negentropic action reduces information redundancy. This has profound implications for understanding consciousness as nonmechanical action channeled through negentropic force when the rate of change of quantum entropy is zero.

Keywords: Entropic pilot wave theory, photon quasiparticles, conjugation, nanocavity, quasipolaritonic condensate, protein pores, proton motion, dynamic organicity, consciousness.

1. Introduction

The landscape of consciousness has widened (Kuhn, 2024). Over the past few years, our understanding of the brain's complexity has significantly transformed with the development of multiscale neuroscience. The concept of the mind has persisted over millennia, unaffected by Darwinism, and with it fosters the mind-body (brain) problem in the philosophy of mind. The philosopher Ryle (1949) argued that the "mind" is a philosophical illusion hailing chiefly from René Descartes and sustained by logical errors and 'category mistakes' that have become habitual. With the development of the concept of the multiscale brain and multiscale neuroscience, the mind vanishes, and we are liberated from Cartesian dualism. This mindlessness challenges the traditional belief that the mind-body problem is part of neuroscience. Instead, a new paradigm based on the multiscale brain suggests that the mind evanesces in a brain with multiple informational channels, as Dennett (1991) posits in the multiple drafts model of consciousness. It suggests that consciousness is not a product of a central 'self' but rather a dynamic and distributed process within the brain, operating through multiple informational channels in parallel, culminating in the perception of a unified conscious experience.

The dynamic organicity theory (Poznanski, 2024a, b) is a precognitive theory of consciousness based on the irreducibility of dynamic organicity. The dynamicity establishes that proteins are labile and functionally robust. They are continuously remodeled, and membrane protein turnover rates vary over several days, but the functional core remains intact due to protein kinetic stability (Sanchez-Ruiz, 2010), including aromaticity, which is associated with delocalized π -electrons in nonpolar hydrophobic cavities containing benzene ring molecules (Crawford et al., 2018). In biophysical chemistry, a conjugated system is a system of connected p-orbitals with delocalized π -electrons in a molecule. This delocalization of π -electrons is termed π -electronic conjugation. Different extents of π -electronic conjugation can be realized in a single molecule modulating the proton transfer (Demchenko, 2023).

Neural chemistry suggests that molecules do not behave as wave-particle assemblies, which causes their quantum wave functions to decohere. The decoherence

of the wave function in quantum mechanics is replaced with the polarization wave function (ψ_n) and associated entropic pilot waves pervading the entire molecular structure, guiding the delocalized electron ensembles with respect to their phase differences. At the molecular scale, the similarity of the quantum-mechanical Schrödinger equation to the wave-propagation equation in π -electronic conjugation is equivalent to solving Schrödinger equation for the polarization wave function (ψ_n) which is dimensionless and describes the instantaneous state of the enveloping field density of molecular dipole-bound electrons (Poznanski et al., 2019). The wave function," proposed by Pribram (1991), exhibits wave propagation, circumventing the need for quantum states at the molecular level in brains.

In fluorescent proteins containing aromatic amino acid residues such as tryptophan, phenylalanine, and tyrosine, the residues of aromatic amino acids contain benzene rings with resonant delocalized electron orbitals. The coupling of proton motion to delocalized π -electron densities is pivotal in explaining how quasipolaritonic waves exist because of fluorescent proteins' absorption-emission processes (Shi et al., 2017). While plants use quantum coherence for energy transfer, microtubules in neurons have exhibited quantum energy transfer (Kaka et al., 2023), but this does not suggest a role in consciousness as a distributed process. Why proteins and not microtubules? Both contain aromatic amino acid residues (nonpolar regions). Yet π -electron delocalization inhibited the intramolecular proton transfer process in polymers (Tarkka & Jenekhe, 1996). Therefore, it is suggested that microtubules composed of polymers do not use this mechanism.

The hydrated excess protons contribute to the polarization wave component of the polaritonic condensate, i.e., quasipolaritons where it was shown that temperature increased quantum spin transfer (Bhattacharya & Raha, 2013). However, hydrogen bond contributions stabilize the polaritonic wave in hydrophobic cavities (Ragvanderetal et al., 2009). The result is a cavity quasipolariton condensate whose macroscopic properties are dominated by quantum interactions, not through superradiance (Jibu et al., 1994; Nishima et al., 2024; Babcock et al., 2024), but organized quantum interactions like a Bose-Einstein

condensate in noisy, warm, and wet environments (Hameroff, 1994; Hameroff & Tuszynski, 2004; Hameroff *et al.*, 2002; Das *et al.*, 2013).

Similarly, dipole oscillations displace π -electrons in amino acid residues in brain function (Crawford *et al.*, 2018), resulting in the dipole excitation component of the polaritonic condensate. The photonic wave component of the polariton condensate is a non-charged bare polariton (Matsuura & Wasaki, 2014). Matsuura & Wasaki (2014) considered non-charged polaritons as quantized polarization waves in the Ranvier of axons generated from action potential assumed the propagation of the quasipolaritons in axons, introducing a system of equations for the quantized electromagnetic fields, using a matrix approach for the Schrödinger's equation.

Quasipolaritons are hydrated polaritons bound to water molecules by electrostatic (Coulombic) forces. Most of the time, quasipolaritons can overcome thermal noise by increasing the kinetic energy comparable to the thermal noise energy. The quasipolariton enables the self-organization of dissipative structures and interactions of the self-organizing system to be sufficiently strong to be described by a single polarization wave, the so-called cavity quasipolariton condensate. The action of the cavity quasipolariton condensate is not lasing (Del Giudice *et al.*, 1988) but energy transfer through internal energy fluctuations.

Hameroff (1987) reflects on London dispersion forces producing instantaneous dipoles. Coulombic attractive forces are electrostatic forces between nonpolar molecules, including London dispersion forces. In more recent work, Hameroff (2006, 2022) has suggested that quantum dipolar oscillations are induced by polarizability densities (London forces) where quantum interactions may occur in nonpolar "pockets" of benzene ring molecules. Certain force interactions (London interactions) of molecular charges are said to occur between the nonpolar pockets of the cyclic hydrocarbon molecules, polarizing charges extremely quickly. The polarizability of molecules is the property of flexible charge distribution, which interactions with charges outside a molecule may distort. Thus, the London force is the formation of temporary dipoles in the electron clouds of nonpolar molecules.

The cavity polaritonic Bose-Einstein condensate model may give rise to intentionality through a repulsive force that does not lead to the separating of the interacting molecules but involves entropic pilot waves arising from thermo-quantum fluctuations (Conrad, 1996).

This paper focuses on the dipole excitation component of the quasipolariton in cavities and how it evolves from proton motion strongly coupled to π -electron delocalization in benzene rings of aromatic amino acid residues at the molecular scale. The entropic pilot waves lead to changes in motion through information-based action as attributes of intentionality.

2. Quantized dipole excitation waves as a conduit for quasipolaritonic condensates

Bioenergetics of proton transfer for stabilization of the polaritonic waves in hydrophobic cavities within protein pores must be continuous for polaritonic waves. The protonic "wet wires" proton transport is not continuous (Cukierman, 2003). Instead, π -electronic conjugation in hydrophobic cavities is a continuous proton transfer mechanism and does contain water molecules, as evidenced using crystallography (Vaitheeswaran *et al.*, 2004). The thermo-quantum fluctuations are not free *de Broglie waves* but polaritonic wave packets transporting energy. The polaritonic wave packets are due to a strong coupling between protonic motion and delocalized polarization waves (Demchenko, 2023). Polaritonic wave packets carry away the quasi-free electrons kinetic energy¹, giving rise to quasipolaritons as electrical solitons shown in the equivalent circuit in **Fig. 1**.

The action of the cavity quasipolariton condensate is represented in terms of the photonic light-emitting diode in series with a thermistor diode (see **Fig. 1**). An analog electronic circuit of a proton-transfer medium is dependent on temperature. The photodiode emits photons into a proton-transfer medium representing a quasipolariton. The thermistor diode is used to perceive the temperature change and amplifies the signal source stored by the nonlinear capacitor. The resultant signal propagates as an electrical soliton.

¹Quantum polarization waves in benzene rings carry away their quasi-free electron's kinetic energy upon interactions.

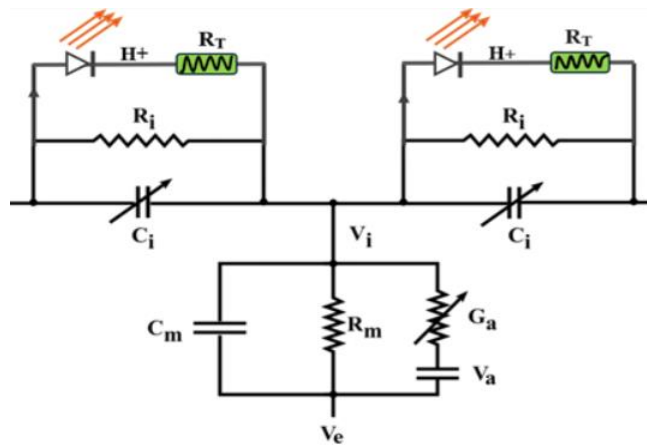


Figure 1. An analog electronic circuit of a proton-transfer medium is dependent on temperature. A protonic light-emitting diode (H^+ LED) (Langer *et al.*, 2020; Schulte *et al.*, 2021) and a thermistor diode represent the quasipolariton. The photodiode emits photons into a proton-transfer medium. The thermistor diode is used to perceive the temperature change and amplify the signal source stored by the nonlinear capacitor. The resultant electrical soliton propagates, carrying information induced by the polarization wave as a conduit for the quantum effect of the quasipolariton.

The quantized polarization wave embedded in a proton molecular chain that comprises the quasipolariton propagates at sound speed ($v=1500\text{m/s}$) in water, much slower than the velocity of light (c) (i.e., $v \ll c$). The size of the bare polariton as a quasiparticle wave is at most 25nm (Del Giudice *et al.*, 1985). Still, the quasipolariton is much larger within the limits of coherent domains of interfacial water (100nm). The water molecule is 0.1 nm , and the ‘wetness’ of water approaches the bulk scale of over 2nm , so the nanocavity is not “wet”. Furthermore, protein pores are not “soft matter” (over 10nm) but depend on

thermal processing and thermal energy scale when confined to nanocavities less than 2 nm . The proton is the major player in soliton formation; the polarization wave is also suggested to guide the quasipolaritons within nonpolar ‘nanocavities’. The protein pore is a medium for informational pathways. They function like microtubules throughout the neuropil, including proteinaceous structures where microtubules are absent. Nanocavities in protein pores contain a narrow zone of protons, as positively charged hydrogen ions, which can move in water due to the excitation generated by π -electron delocalization (see Sobczyk *et al.*, 2005 for a review).

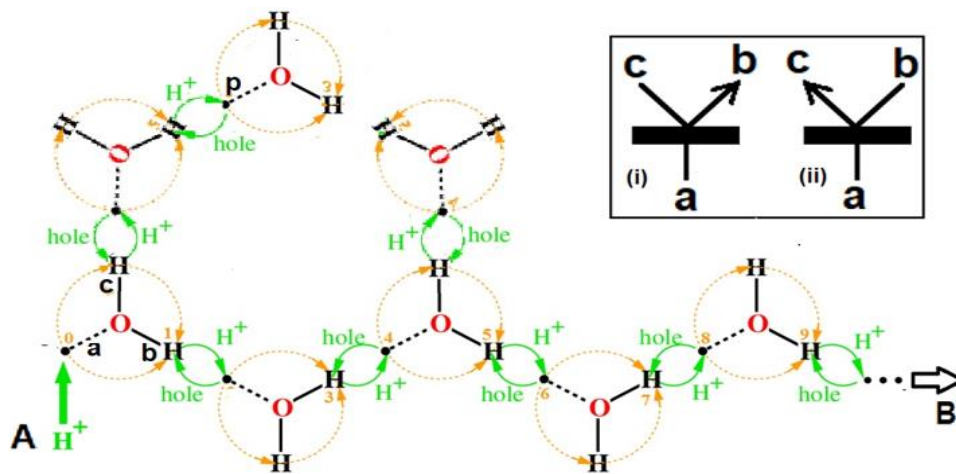


Figure 2 Proton waveguide transporting a hydrogen ion from point A to point B depicted by the Feynman path technique. The letters a, b, and c are marked three water molecules from the left in this figure. It is a wet transistor. Its working is shown in the rectangle from the right above. Two possible states of the transistor are shown in this rectangle: (i) channel b is open, channel c is closed; (ii) channel b is closed, and channel c is open; channel a is entering a hydrogen ion, exciting an optical phonon in the chain around the oxygen atom. Yellow arrows drawn on a cycle around the oxygen atom mark optical phonons induced by hydrogen ions pushing.

What is communicated by a cavity quasipolariton? **Figure 2** shows the Feynman path of the proton along the proton waveguide. The proton (the hydrogen ion H^+) migrates from point A to point B. As seen in **Fig. 2**, the hydrogen ion moves from left to right. While the hole (an empty place not occupied by the hydrogen ion) is moved in the opposite direction. It is a quantum tunneling process (Gray & Winkler, 2009). Hydroperoxide ions (OH^-) excitons interact with photon quasiparticles, resulting in a bound state within which the energy quanta condense—Bose-Einstein condensate. However, in the noisy, warm, and wet medium of the brain, the Bose-Einstein condensate would be unstable because of the polarized regions in the vicinity of ions. Still, cavity polariton condensates are stable at room temperature in nonpolar regions where delocalization occurs (Dietrich *et al.*, 2016).

How does the polariton condensate cause stability? The Bose-Einstein condensation is the entanglement of photon quasiparticles, so the system self-organizes into a stable state. It was theoretically proposed that microtubules may shield these effects (Jibu *et al.*, 1994), and experimentally, it was shown that energy transfer takes place (Kalra *et al.*, 2023). Still, the electronic coupling between transition dipoles is weak (Babcock *et al.*, 2024). However, quasipolariton guided by its polarization wave component that is induced by π -electronic conjugation does not require a strong coupling; it requires photon quasiparticles, resulting from interactions between H^+ ions, with kinetic energy 10^{-5} times smaller than thermal noise in neurons (Matsuura & Wasaki, 2014). To resist thermal noise, bare polaritons attract the additional mass of interfacial water molecules and build their kinetic energy by propagating in a hydrophobic cavity within protein pores where such quasipolaritons result from ion-dipole interactions. The Bose-Einstein condensate is a state that persists at room temperature if induced by quasipolariton formation (Matsuura & Waskai, 2014).

3. The negentropic action of the dipole excitation wave in protonic waveguides

The polarization wave in cavity polaritonic Bose-Einstein condensate due to dipole excitations arises because the π -electrons are subjected to a constant potential due to the endogenous electromagnetic field produced by the protonic ions. The proton motion in

waveguides is governed by the ‘action’ function in phase-space (Meijer *et al.*, 2021; Poznanski *et al.*, 2022b):

$$\frac{\partial \nabla S}{\partial t} + \left(\frac{1}{2m}\right) \nabla \cdot (\nabla S - q\mathbf{A})^2 + q\nabla\phi + \mathbf{V}(t)m \frac{\partial \nabla \ln(\rho)}{\partial t} + \nabla(Q_{sq} + U) = 0 \quad (1)$$

Here $S(x,t)$ is the ‘action’ function that has the dimension of [energy][time], t is time, m is the effective mass of protons, ϕ is the electric potential, \mathbf{A} is vector potential that underlies the determination of the orbital velocity, \mathbf{V} is the kinematic viscosity of the water medium in [length]²/[time], ρ is the current density of protons, q is the electron charge, ∇^2 is the Laplacian, U is the ‘pressure’ energy, and the negentropically-derived (thermo-quantum) internal energy of an open quantum system (Q_{sq}) (Sbitnev, 2008; Poznanski *et al.*, 2022a):

$$Q_{sq} = -\frac{\gamma^2}{2m} (\nabla S_Q)^2 + \frac{\gamma^2}{2m} \nabla^2 S_Q = Q_k + Q_p \quad (2)$$

where γ the action parameter carries dimensions of [energy][time]. The first term on the RHS of Eqn. (2) is viewed as the quantum kinetic energy (Q_k), and the second term on the RHS as the quantum potential energy (Q_p). Equation (2) describes a sum of two negentropic ‘correctors’ of the internal energy for an open quantum system linked with the quantum entropy (Sbitnev, 2008; Fiscaletti, 2012):

$$S_Q = -\frac{1}{2} \ln(\rho) \quad (3)$$

This is not the von Neumann entropy in units of the Boltzmann constant. The entropic version of de Broglie-Bohm theory assumes that it is the probability density associated with a quantum wave function. Here, the reference to ‘quantum-like’ suggests dependence on a polarization wave function that describes quantum dipolar oscillations. These oscillations are not probabilistic; the pattern is chaotic, driven by internal energy fluctuations governed by Eqn (2).

We define Q_{sq} to be thermo-quantum internal energy, representing the mesoscopically aggregated effect of the microscopic random thermo-quantum fluctuations. The thermo-quantum internal energy represents microscopic thermal motion or fluctuation. This is an analog of Boltzmann-Gibbs classical entropy to the

realm of quantum hydrodynamics, but a perfect analogy does not exist. According to Heifetz & Cohen (2015), the fluctuation from the mean is represented by the imaginary part of the momentum (∇S). Therefore, in terms of the thermo-quantum fluctuations in the internal energy (Q_{sq}) it can be both temporally positive or negative in amplitude, depending on how the internal energy is redistributed between the quantum kinetic energy (negative values) and quantum potential energy (positive values).

The thermo-quantum fluctuations exert competing effects and become ‘mixed’ as thermal and quantum fluctuations. This can be observed with the temperature dependence of the internal energy. We note that $\frac{\nabla E}{\nabla S^*} = T$ (Tsekov, personal communication), where S^* is the entropy and $E = -\frac{\partial S}{\partial t}$ is the total energy. It is possible to find the internal energy as a function of T . Since the Boltzmann-Gibbs thermal entropy is dimensionless, the connection is established by multiplication by the Boltzmann constant k_B . First, we note that $\nabla S_Q = \left(-\frac{1}{2k_B}\right)\nabla S^*$ and from Eqn (2), we have (Poznanski et al., 2022b):

$$Q_{sq} = -\frac{\gamma^2}{8mT^2k_B^2} \left[\nabla\left(\frac{\partial S}{\partial t}\right)\right]^2 + \frac{\gamma^2}{4mTk_B} \nabla^2\left(\frac{\partial S}{\partial t}\right) \quad (4)$$

where T is the temperature in Kelvin, note that the temperature-dependent quantum energy depends on the derivate over time of the ‘action’ function. In quantum potential chemistry, the internal energy depends on the ‘action’ function and the temperature (T), so it is a multiscale concept from micro to macro.

The internal energy dependence on temperature and the rate of change of phase difference (i.e., the derivative over time of the ‘action’ function) as fluctuations (f) gives the following definition (Alemdar et al., 2023):

$$Q_{sq} = -\frac{\gamma^2}{8mT^2k_B^2} (\nabla f)^2 + \frac{\gamma^2}{4mTk_B} \nabla^2(f) \quad (5)$$

where T is the temperature in Kelvin, k_B is Boltzmann’s constant in units of [energy]/Kelvin, f is thermo-quantum fluctuation in units of [energy], γ is a spread function parameter in units of [energy][time], t is time [time], m is the effective mass of protons in units of [mass], ∇ is the gradient in units of [length]⁻¹, and ∇^2 is the Laplacian in units of [length]⁻².

We have followed Dennis et al. (2015) in calling the quantum potential energy ‘internal energy’ with the addition of quantum kinetic energy (Hiley, 2002), where ‘active’ information contributes to the redistribution of the internal energy shared between the kinetic and potential parts. Given the underlying quantum influences of the molecular scale which impact the fundamental brain dynamics, we dispense with a quantum ontological formalism based on the Bohmian quantum potential (Bohm, 1952) and replace it with Brownian motion communicated to the molecule according to hydrodynamic pilot wave theory (Nelson, 1966; Mollai et al., 2013) or as ‘concealed’ motion through quantum degrees of freedom (Holland, 1993, 2015).

We avoid defining electron density in terms of all present electrons, as suggested in the quantum theory of atoms in molecules (QTAIM) (Arriaga et al., 2019; Matta et al., 2020). Instead, we focus on delocalized electrons in dipolar-bound molecules, ignoring any interactions between electrons. Like QTAIM, we avoid reference to chemical bonds since they are essentially classical, and like the topological atom of QTAIM, which goes beyond the quantum state and considers ‘quantum-like’ internal energy fluctuations in cavities.

The thermo-quantum fluctuations of the internal energy are negentropic ‘corrections’ to the dipolar excitation wave consisting of the quantum potential energy in units of [energy] (Boeyens, 2000, 2008):

$$Q_p = \sum_{j=1}^n \frac{\gamma^2}{2m} \frac{\nabla_j^2 \rho^{0.5}}{\rho^{0.5}} \quad (6)$$

and the quantum kinetic energy in units of [energy]:

$$Q_k = -\sum_{j=1}^n \frac{\gamma^2}{2m_j} \frac{(\nabla_j \rho^{0.5})^2}{\rho} \quad (7)$$

where ρ is the density distribution of dipole-bound delocalized electrons (dimensionless), m is the mass of the delocalized electron in units of [mass], the ‘action’ parameter ($\gamma > 0$) carries a dimension of [energy][time] is the proportionality constant relating the velocity of flow of the quasi-free electron density to the gradient of the action function, and ∇^2 is the Laplacian.

Q_k is the quantum kinetic energy when delocalization occurs far from the dipolar core or nuclei, where the Coulombic attraction force becomes negligible, and

pilot wave forces take over. This signifies a ‘repulsive force’ (or negentropic force) as an information-based action as internal energy transduction from quantum potential energy to quantum kinetic energy but does not separate the interacting atoms in molecules, like the Pauli repulsion force which is negligible.

4. How entropic pilot waves influence the ‘dancing’ of delocalized electrons

The Schrödinger equation is a mathematical equation that describes how a quantum state evolves and is no longer applicable since no quantum state is assumed to exist. Instead, the molecular scale is quantum-like because of decoherence and the diffusion of the quantum state. Schrödinger-like equation explicitly incorporates the negentropically-derived quantum potential energy in terms of microscopic and macroscopic scales based on quantum statistical mechanics (mixed states, thermal mixed states, etc.), where quantum entropy is considered to involve topological states of matter in the topological space (e.g., functionality space) represents a new class of materials characterized by nonlocal effects arising from purely local quantum degrees of freedom.

The phase difference in electron enveloping fields governs the dipolar oscillations that control dipole-bound orbital global dynamics of the quasi-free electron densities in cavities (see **Fig. 3**). Consequently, phase differences of the oscillating dipole-bound delocalized electrons are reflected by the ‘action’ function (S) of the dimensionless *polarization wave function* (ψ) describing the instantaneous state of the enveloping field density of dipole-bound delocalized electrons induced by the polarization wave component of the quasipolariton as described by a Schrödinger-like wave equation (Gould, 1975; Pribram, 1991):

$$i\gamma \frac{\partial \psi}{\partial t} = -\frac{\gamma^2}{2m} \nabla^2 \psi + U\psi \quad (8)$$

where the imaginary number $i = \sqrt{-1}$, and $U = \frac{\gamma^2}{8m} \left(\frac{\nabla \rho}{\rho}\right)^2$ being the ‘pressure’ energy in units of [energy]. This Schrödinger-like equation assumes a density distribution of quasi-free electrons bound to a molecular core. Schrödinger-like wave equation describes the quantum dipole oscillations of dipole-bound delocalized electrons in a cavity of length L.

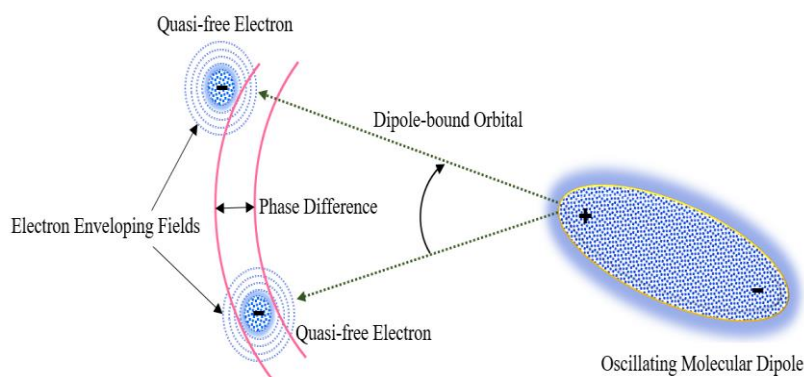


Fig. 3. A schematic illustration of two dipole-bound delocalized electrons that depend on the electric dipole moment of the oscillating molecular dipole. The oscillating molecular dipole located in electrolytic regions has a nonzero orbital angular momentum, which enables the quasi-free electrons to follow the motion of the positive pole that acts as a pseudo-nucleus for the quasi-free electrons. The phase differences between the quasi-free electrons associated with their molecular orbital (dipole-bound orbital) are described in terms of the delocalized macro-quantum wave function, which is a mathematical function describing the wave-like behavior of the dipole-bound delocalized electrons located in hydrophobic cavities. [Adapted from Piela (2014)].

Substituting the Madelung transformation $\psi = \sqrt{\rho(x,t)} e^{iS(x,t)/\gamma}$ into Eqn (8) and upon separating the imaginary and real parts. The imaginary part leads to a continuity equation (not shown), and the real part describes how the density of molecular dipole-bound delocalized electrons is represented by the phase difference expressed in terms of the neural Hamilton-Jacobi equation (Gould, 1975):

$$\frac{\partial S}{\partial t} + \frac{1}{2m} (\nabla S)^2 + U + Q = 0 \quad (9)$$

where $S = \frac{i}{2} \gamma \ln \frac{\psi^*}{\psi}$ is the ‘action’ function attributable to the phase differences of oscillating dipole-bound delocalized electrons in units of [energy][time], ψ^* is the complex conjugate of polarization wave function and ∇ is the gradient (in one-dimension $\equiv \frac{\partial}{\partial x}$), the temporal scale of the dipolar fluctuations (t), γ is a positive ‘action’ parameter in units of [energy][time] relating the velocity of flow of the quasi-free electron density (v) in units of [energy][mass][length] to the gradient of the action function ∇S , via $v = \gamma \nabla S$, and Q is the internal energy in units of [energy] (Poznanski et al., 2018, 2019):

$$Q(x,t) = -\frac{1}{2m} \gamma^2 \frac{\nabla^2 \sqrt{\rho(x,t)}}{\sqrt{\rho(x,t)}} \quad (10)$$

where $\rho(x,t)$ is the density distribution of dipole-bound delocalized electrons (dimensionless), x is the length scale and ∇^2 is the Laplacian (in one-dimension $\equiv \frac{\partial^2}{\partial x^2}$). The non-classical nature of internal energy (Q), like the quantum potential (Bohm, 1952), is an information potential.

If we introduce the case of constant ‘pressure’ energy $U = \frac{\gamma^2}{2mL^2}$ or $\frac{\nabla \rho}{\rho} \sim \frac{2}{L}$ then the solution of Eqn (8) is readily found via the transformation:

$$\psi(x,t) = \psi_0(x,t) e^{-\frac{i}{\gamma} U t} \quad (11)$$

and the enveloping field density distribution $\rho(x,t) = |\psi_0|^2$ where $\psi_0(x,t)$ satisfies a reduced Schrödinger-like wave equation:

$$i\gamma \frac{\partial \psi_0}{\partial t} = -\frac{\gamma^2}{2m} \nabla^2 \psi_0 \quad (12)$$

The separation of variables method gives a solution of the Schrödinger-like wave equation for a cavity length L [length] (average dipole-bound delocalized electron distance), subject to Dirichlet boundary conditions as the *polarization wave function* (ψ) (dimensionless) (Pribram, 1991; Poznanski et al., 2019):

$$\psi_0(x,t) = \left(\frac{1}{L}\right) \sum c_n e^{-\frac{2i}{\gamma} \left(\frac{\gamma^2}{mL^2} \pi^2 n^2 t - \frac{\gamma}{L} \pi x\right)} \quad (13)$$

where C_n are Fourier coefficients independent of time in units [length], and L is in units of [length]. The *polarization wave function* (ψ) is a wave of quasiparticles that describes how quantum dipole oscillations evolve at the molecular level.

In Fig. 4, both the real and imaginary components of the *polarization wave function* are shown for $L=1, \gamma = 1.0, x=0.1$ (see Fig. 4(a)) and for $L=0.1, \gamma = 0.01, x=0.01$ (see Fig. 4(b)) to be periodic every 0.32-time units. However, reducing the parameters increases the amplitude significantly in the temporal variation of the *polarization wave function*. Internal energy fluctuations of the quantum dipole oscillations are given by the imaginary part of ψ and the real part of ψ signified by the average dipole oscillations.

The action function (also known as phase function) (S) is shown for $L=1, \gamma = 1.0, x=0.1$ and for $L=0.1, \gamma = 0.01, x=0.01$ in Fig 5. The amplitude was clipped between $-\pi$ and π . The imaginary part of S gives internal energy fluctuations from the average phase differences of the quantum dipole-oscillations, and the average phase differences signify the real part of S. This imaginary part of S signifies how the internal energy is redistributed between the quantum kinetic energy (negative values) and quantum potential energy (positive values). The phase difference in the imaginary component depends on values of L, γ , and x, with Fig 5(a) indicating a slight distribution from the quantum kinetic energy, while in Fig 5(b), there is no contribution from the quantum kinetic energy. This suggests that the action of quantum potential energy rather than quantum kinetic energy facilitates negentropic action.

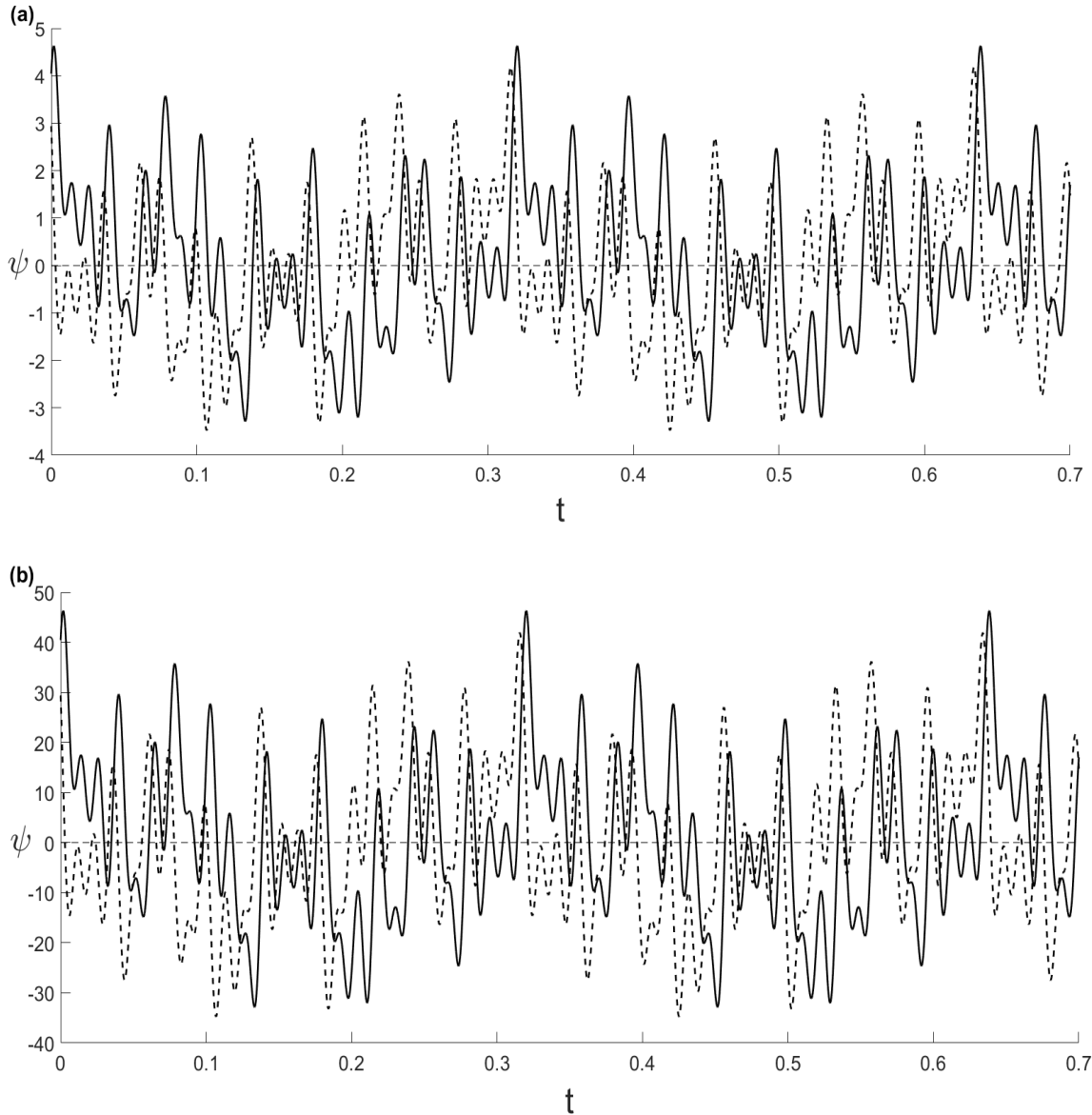


Fig. 4. The polarization wave function (ψ) versus time (t) for $L=1, \gamma = 1.0, x=0.1$ (a) and for $L=0.1, \gamma = 0.01, x=0.01$ (b). The imaginary component describes internal energy fluctuations across the mean of quantum-dipole oscillations. The real component is shown as a continuous line and an imaginary dashed line.

Both real and imaginary components of S have unique patterns that may signify informational content influenced by the shape of the enveloping active field density. The internal energy (Q) implicitly consists of negentropic ‘correctors’ linked with the quantum entropy that produce negentropic action (or the action of S). However, the earlier work of [Poznanski et al. \(2018,2019\)](#) lumped negentropic action acted upon by the internal energy without delineating explicitly whether quantum potential energy or quantum kinetic energy. We define *intrinsic information* occurring through an informational pathway derived from the

continuity equation when $\nabla S=0$ to be the following:

$$\frac{\partial S_Q}{\partial t} = 0 \quad (14)$$

The condition $\nabla S=0$ indicates that the quantum kinetic energy $\frac{1}{2m}(\nabla S)^2 - \frac{\gamma^2}{2m}(\nabla S_Q)^2$ is negative. Internal energy influences negentropic action through pilot wave force (negentropic force). At negative quantum kinetic energy, the rate of change of quantum entropy is zero, signifying that the negentropic action acts as an informational pathway and facilitates the movement of information-based action for information encoding.

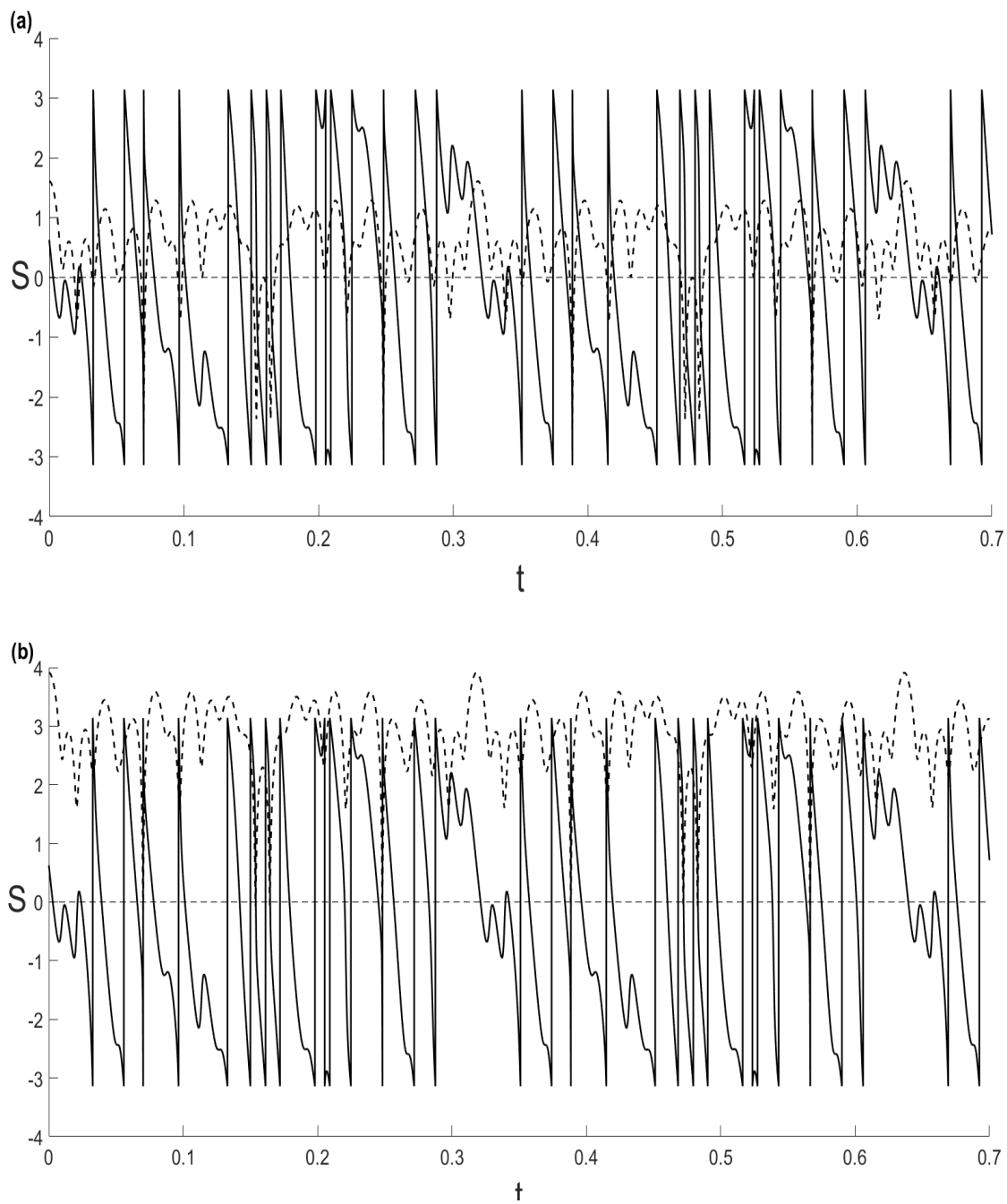


Fig. 5. Phase differences of oscillating dipole-bound delocalized electrons reflected by action function (S) versus time (t) for $L=1$, $\gamma = 1.0$, $x=0.1$ (a) and $L=0.1$, $\gamma = 0.01$, $x=0.01$ (b). The phase coherence of the quantum dipolar oscillations is only in the real component of the phase function. Its amplitude varies between $-\pi$ and $+\pi$. The imaginary component of the phase function amplitude was not bounded and varied depending on the choice of parameters. The real component is shown as a continuous line and an imaginary dashed line.

The ‘action’ function, whose dynamical evolution is under the action of the classical potential energy (U) and the internal energy (Q). The latter would bring entropic pilot waves coordinating the movement of electron densities in cavities for the dynamical evolution of the phase of the quantum dipolar oscillations, and this is represented by ∇S as the momentum in SI units of [energy]/[time]/[length]=[mass][length]/[time] (Poznanski *et al.*, 2019,2022a):

$$\nabla S = i\gamma \left(\frac{1}{\sqrt{\Psi^*}} \frac{\partial \sqrt{\Psi^*}}{\partial x} - \frac{1}{\sqrt{\Psi}} \frac{\partial \sqrt{\Psi}}{\partial x} \right). \quad (15)$$

It is evident from **Fig.6** that the entropic pilot waves

guide the dipole oscillations in phase S . The momentum is determined by the gradient of the phase of the polarization wave function (ψ), that is, ∇S . Equation (15) is an irrotational hydrodynamic-like velocity with the orbital velocity vector potential \mathbf{A} ignored. The imaginary component depends on both quantum kinetic energy and quantum potential energy. The negative quantum kinetic energy of the dipolar excitation waves (not just internal energy) indicates that the momentum is zero, and the negentropic action acts as an informational pathway that facilitates the movement of information-based action for information encoding. This suggests that the negentropic action of quantum potential energy facilitates the movement of information-based action through quantum kinetic energy (see **Fig. 6**).

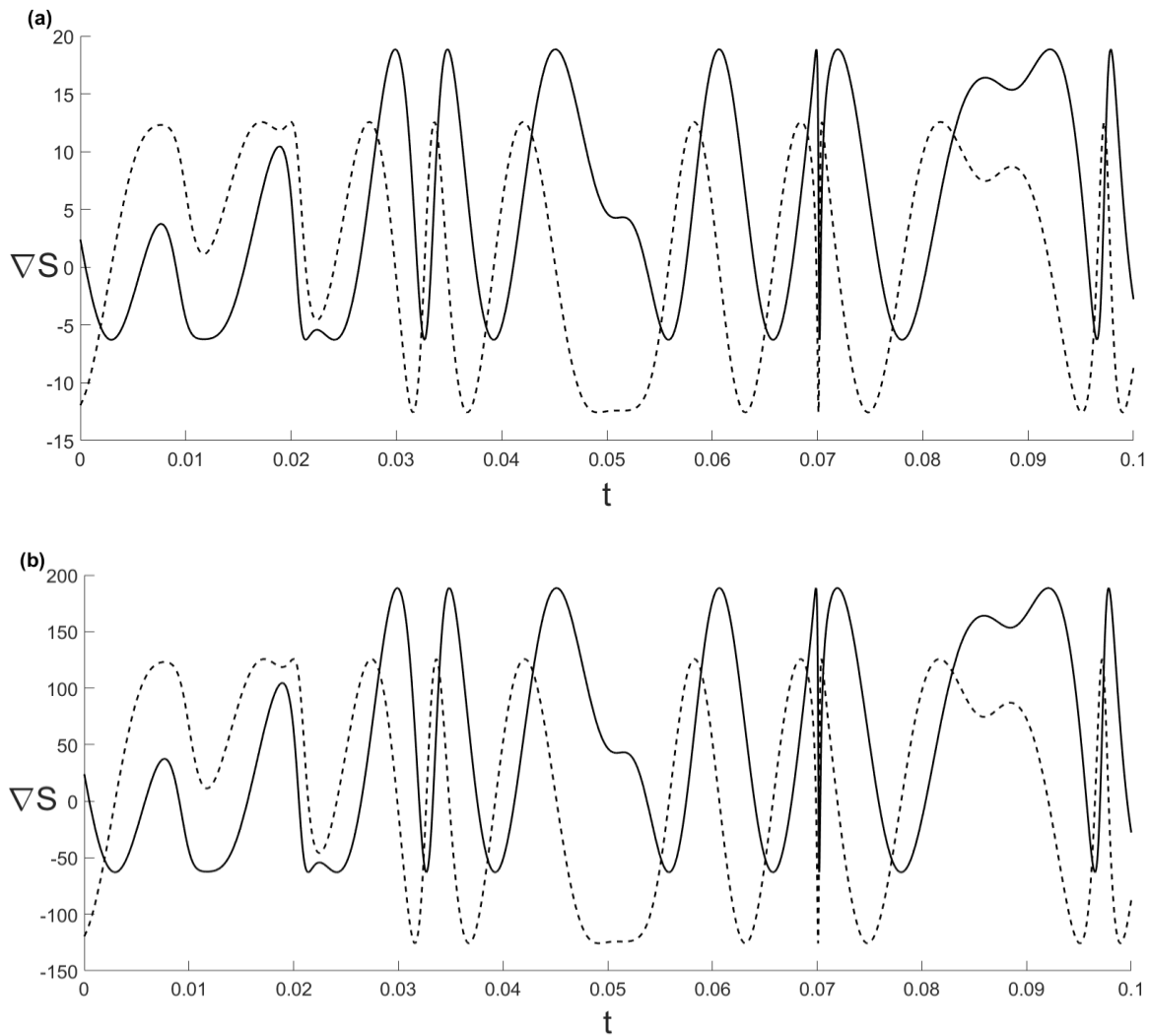


Fig. 6. Momentum (∇S) versus time (t) for $L=1$, $\gamma = 1.0$, (a) and $L=0.1$, $\gamma = 0.01$ (b). The entropic pilot waves coordinate the movement of delocalized electron densities for the dynamical evolution of the phase in the quantum dipole oscillations. The internal energy fluctuations (dashed line) approximate the average dipole oscillations in phase (continuous line). The real component is shown as a continuous line and an imaginary dashed line.

We consider the Born rule, linking the amplitude of the polarization wave function to the density distribution of dipole-bound delocalized electrons: $\rho(x, t) = |\psi|^2$ (Tsekov, 2012), between points $x=0$ and $x=L$ is given by:

$$P(0 \leq x \leq L) = \int |\psi|^2 dx \quad (16)$$

The density distribution is found to follow a sharp-peaked curve like a delta function at a particular time that is dependent on values of L and γ (see Fig. 7). What is particularly interesting is the chaotic profile of the density distribution, which measures the intensity of the polarization wave function.

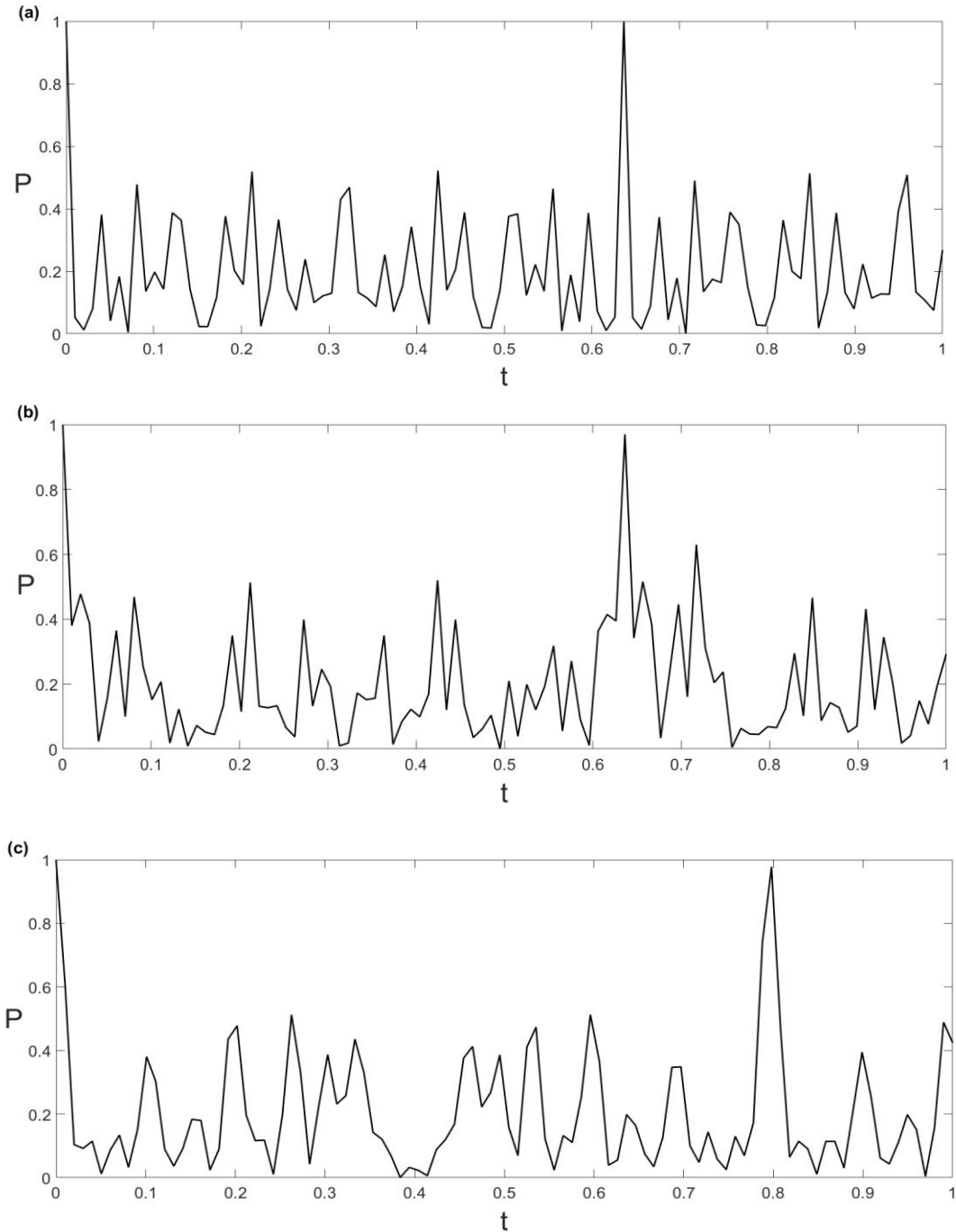


Fig. 7. The time-dependent density distribution (P) for (a) $L=1, \gamma = 1.0$ (b) $L=0.5, \gamma = 1.0$. and (c) $L=0.5, \gamma = 0.1$. The profile measures the intensity of the polarization wave function, which is shown to be chaotic.

5. Discussion

5.1. *The negentropic action of entropic pilot waves as intentionality*

The prevailing perspective on consciousness suggests that consciousness is entropic (Lugten, 2024). Consciousness at the molecular level must also include the unique material composition of the brain as active matter. Photon quasiparticles have intrinsic properties that depend on the material composition of the brain. We focused on these intrinsic properties, namely internal energy's profound effect on energy transduction mechanisms that create new information pathways and the effect of information-based action upon the material constituency of the brain through a 'repulsive force' that does not lead to the separation of interacting atoms in molecules. The basis of such 'repulsive force' is entropic pilot waves that guide quantum potential energy (as quantum potential information) in new information pathways through quantum degrees of freedom. In other words, entropic pilot waves act upon the quantum potential energy to form an information pathway for creating quantum potential information. Quantum potential information is the potentiality of experientiality, and the motion of information-based action is the actuality of experientiality. The process of how information-based action can create experientiality is suggested to be a manifestation of quantum kinetic energy directed at reducing informational redundancy (also referred to as intentionality).

The rubric of consciousness is intentionality (Searle, 1980). It refers to the underlying experience of acting as an understanding of uncertainty (Poznanski *et al.*, 2023). In understanding uncertainty, the notion of intentionality as the experience of acting suggests that it is a defining aspect of the consciousness mechanism and ceases to exist upon the complete removal of uncertainty, in which case memory begins (Solms, 2014). Intentionality is an experience of acting to reduce uncertainty that leads to understanding at the molecular level, but the process of reducing uncertainty revolves around negentropic action. Kováč (2006) further suggests that a labile protein exhibits 'molecular sentience.' Van der Waals forces drive protein folding, but sentience requires a temporal wave (Peraira & Aguiar, 2022) and does not

require cognition (Pereira, 2021). This dynamic nature of the protein molecule stems from entropic pilot waves. The negentropic action exhibits sentience when proteins change their conformation in response to a signal, imbuing the process with 'meaning.' The various potential actions of a protein folding process are determined by the protein's different possible functional forms or conformations. Conformational changes require energy with negative entropy, and when this energy has negative quantum kinetic energy, the protein molecule displays intentionality.

5.2 *Encoding multiscale redundancy supplements the binding problem*

The prevailing notion in molecular biology is that information is distributed holographically, and each part contains information about the whole system (van Regenmortel, 2024). We must challenge this concept because information is distributed across scales in the multiscale brain, presenting a new perspective; information is created through the intricate web of quantum degrees of freedom. This process occurs via novel information pathways to explore how the intrinsic quantum processes play a role in epistemic subjectivism, defined as precognitive subjective experienceabilities. Each scale has its information, which is not transferred but forms a redundancy structure from which a particular *meaning* arises due to negentropic action in informational pathways. It elaborates on Karl Pribram's work on information redundancy structures (Pribram *et al.*, 1966) and an extension of Gerald Edelman's degeneracy (Edelman & Gally, 2001).

A multiscale brain is composed of an informational structure of multiscale redundancy. However, decoding this information relative to scale is not as simple as assuming that subjectivity is an attribute of the brain's electromagnetic field that acts upon neurons as a feedback loop because ephaptic coupling promotes synchronous firing, and consciousness is spontaneous. Rather, encoding multiscale redundancy supplements the binding problem (Treisman, 1996). Once decoded from multiscale redundancy at each scale in a self-referential system, the 'meaning' becomes experiential when information is encoded onto higher centers in the brain. If the system is not self-referential, then the 'meaning' cannot be decoded through its multiscale redundancy and 'meaning' is lost. Thus, 'zooming' out

and averaging into a condensed form of information would cause information-based action to be lost. Pursuing the multiscale brain challenges conventional notions, rejecting the brain as a mere Turing machine or information processor. Instead, it introduces the novel concept of self-referential decoding of information, which provides a crucial structure of redundancies, including the same amount of information, defined as ‘repetitions’.

The binding problem is supplemented by encoding multiscale redundancy across informational pathways. Information encoding occurs when the negentropic action of quantum potential energy facilitates the movement of information-based action when the polarization wave momentum is zero, and the rate of change of quantum entropy is zero, leaving a negative quantum kinetic energy. As a result, when functions describe actions at the molecular scale, they can be understood to be decoded (intrinsic) information as part of multiscale brain functioning, which makes the Hard Problem of Consciousness (Chalmers, 1995) an epistemological issue rather than an ontological one.

5.3 Insights on biphoton generation in fluorescent proteins

Biphoton quasiparticles arise at the molecular scale in specific protein pathways (Shi *et al.*, 2017). Fluorescent proteins are amino acids with resonant side-chain structures (conjugate bonds), including phenylalanine, tryptophan, and tyrosine (with aromatic ring). They exhibit delocalized electrons and are intrinsically fluorescent. Tryptophan, the dominant intrinsic fluorophore (Lakowicz, 2006), has residues in transmembrane proteins at the lipid–water interface. Proteins form the internal machinery within brain cells and the connective tissue between brain cells, resulting from transcription factors for gene expression of protein-protein interactions present at a higher density in the mammalian cortex (Suzuki *et al.*, 2004; Suzuki, 2006). Anesthetics are oily compounds soluble in organic solvents and insoluble in polar solvents such as water. They consist of hydrophobic molecules that disrupt this natural arrangement in protein pores, which include aromatic amino acids. The speed of anesthetic actions precludes any direct involvement of genes, and all life can be anesthetized (Baluška *et al.*, 2016), suggesting the dynamic organicity theory of consciousness.

Burdick *et al.* (2019) have shown that anaesthetics interact with entangled photons of a particular wavelength, effectively eliminating consciousness. If this can be extended for any photon wavelength, then a possible connection with cavity quasipolaritonic condensates seems more likely than Froelich-type condensates (Fröhlich, 1975). If cavities contain nonpolar delocalized π -electrons, given that when two p orbitals bind to form a π bond, assuming both delocalized electrons have an opposite spin and during transition emit a photon by accelerating, the photons exchanged could, in principle, be entangled, providing support for a causal relationship between consciousness, and quasipolaritons.

Liu *et al.* (2024) proposed a vibronic cavity polariton as the mechanism of information synchronization in the myelin sheath of axons. There are two major problems with myelin polariton for consciousness. The first is that myelin sheaths like microtubules are limited to neuronal boundaries and cannot solve the binding problem. The origin of the photons is assumed to be chemical reactions in neuronal mitochondria. The other major problem is the assumption that “*the effect of thermal fluctuation on the states of the polariton is negligible*”. To prevent thermalization, the myelin polariton cannot be a bare polariton but is coupled with water molecules, as discussed here with quasipolariton. However, the major problem is that quantum optical coherence is insufficient for consciousness.

6. Conclusion

This paper explored the quasipolariton as the fundamental unit of the consciousness process. The theory limits photon entanglement between π – π electrons in protein pathways, utilizing quantum optical effects and entropic pilot wave theory to harness the notion of intentionality. The negentropic action by a repulsive force, responsible for guidance from entropic pilot waves, reflects a quantum process through negative quantum kinetic energy as a fundamental feature of reality. It is characterized by quantum degrees of freedom in the redundancy structure and decoded relative to scale (multiscale redundancy). The uniqueness of the nonpolar cavities is that they are isolated from diffusive ionic motion, which could, in principle, eliminate a bare polariton from existence. They are uniquely positioned in

pathways of fluorescent molecules in protein pores and across transmembrane proteins throughout the brain.

Conflict of Interest

The authors declare no conflict of interest. Although they serve as Editorial Board members, Erkki Brändas was delegated to the editorial process for this article.

Acknowledgment

Our gratitude goes to the late Harry Friedmann (Bar-Ilan University) for his inspirational vision regarding the cavity polaritonic Bose-Einstein condensate model as the basis for a physical mechanism of consciousness. Special thanks to Eda Alemdar, Geoff Goodman, Alex Hankey, Jan Holmgren, and Ruth Kastner for their discussions on various aspects of the paper. We also thank Lleuve Cacha for the illustrations and Abram Poznanski for technical support. Funding support from UTM (FRGS-4F891) is greatly appreciated (J.A).

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