The photon structure in interference processes, quantum entanglement and self-organized cosmos

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Abstract

The standard framework of cosmology requires evaluating the quantum entanglement of primordial Planck bosons at a same quantum state. A thermodynamic feedback becomes evidence trough the Hubble's law emanating from the comoving volume, responding to the coupling of the flow energy with the imprinted dimensionality of the space-time. The pair formation in which coherence between same quantum states will manifested in an oscillatory superposition. Therefore, two almost simultaneous positions displace a wavelength value. Thus, a small identical time shapes space-time, separating the event-distance between the interactions of two photons. Hence, the energy flow at the microscopic level aligns the evolution into homogeneous phases, indicating the presence of a regulatory process over expansion connected to the universe age under flatness. The distension-contraction due to the interference of the pair of photons (or electrons) involves a sum of angular moments, at the instant of the vector re-configuration of the electric and magnetic fields. Therefore, the transitory wavelength of the photon pair superposition can be characterized by two exclusive states: constructive (distension of the E field) or destructive (contraction of the E field). Quantum entanglement acts as a dissipative coherence-decoherence oscillatory potential, with momentum conservation between rest and inertial mass. Thus, this moderates the increase in entropy as a function of the bottleneck that is the velocity of light: *c*, and preserving the balance between open and closed curvatures, that is, flatness of the expansion.

Introduction

It is conjectured that the primordial universe begins with a quantum entanglement of the Planck bosons. These emerge in a homogeneous, dissipative and coherent state, creating the quasi-continuous-causal space-time. When separating the electroweak force at $10^{-10}\ s$, the radiation density predominates over the expansion of the universe. PDC (parametric down-conversion) would be the process that allows photons split and decrease their frequency, creating space by elongation [1] [2].

Primordial gravitational waves modify the space-time over primordial plasma. Thus, gives rise to baryonic acoustic oscillations (BAO), which are fluctuations in the density of visible baryonic matter (normal matter) in the universe. The BAO matter grouping provides a “standard rule” for the length scale in cosmology [3].

Thus, imprints harmonics of sound into the vibrational frequencies along the star map detected by *lookback on time* [4]. The latter describes evolutionary stages by locating uniformity along ages, differentiating thermodynamically space-time.

Alternatively, Hubble's law applied to the origin allows the recession velocity to be correlated with the space-time coordinates. The elongation of the photons would be thus, synchronized to the dimensionality of the universe. PDC's role in the expansion of the universe requires deepening the internal structure of coherence and quantum entanglement [5].

Results

Interference and consistent sources

Diffraction grating [6]: When the 632.8nm red light from the helium-neon laser strikes a diffraction grating, it is diffracted on each side in multiple orders. Orders 1 and 2 are shown on each side of the direct ray. Different wavelengths are diffracted at different angles, according to the lattice relationship. They are also built to laser in the green at 534.5 nm and in the infrared at 1523 nm.

A diffraction grating is made up of a large number of parallel slits, very close to each other. The condition of maximum intensity is the same as that of the double slit. But with a large number of slits, the maximum intensity is very sharp and narrow, providing high resolution. The angular separation of the maxima is generally much greater because the slit spacing is so small for a diffraction grating. In the network, the peak intensities are also much higher than in the double slit.

When two or more electromagnetic waves overlap in space (interference), the resulting wave at one point and at any time is governed by superposition.

The resulting electromagnetic wave is found by adding the instantaneous displacements that the individual waves would produce at the point if each one occurred alone.

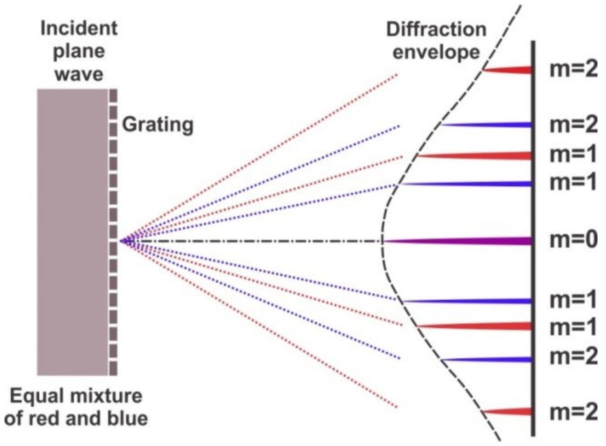

Figure 1: Diffraction grating.

The neon laser (as a monochromatic light source), which emits red light at 623.8 nm with a wavelength range of the order of ± 0.000001 nm, or about a part in 10^9, emitted in $10^{-9}s$ to produce phase vs phase-shift of the studied propagation wave in the space-time.

The experiment can also be performed with electrons, protons or neutrons, producing interference patterns similar to those obtained when performed with light. Using the de Broglie wavelength associated with these particles with mass: $\lambda = \frac{h}{mv}$, h is Planck's constant, *m* is mass and v is velocity.

Constructive and destructive interference

When there is a need to separate light of different wavelengths in high resolution, the most widely used tool of choice is the diffraction grating (or grating). This "super prism" aspect of the diffraction grating leads to its application in the measurement of atomic spectra both in laboratory instruments and in telescopes.

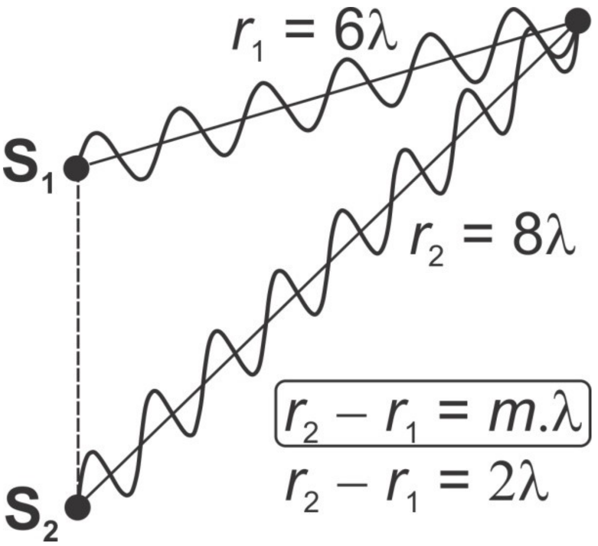

Figure 2.a: Constructive interference.

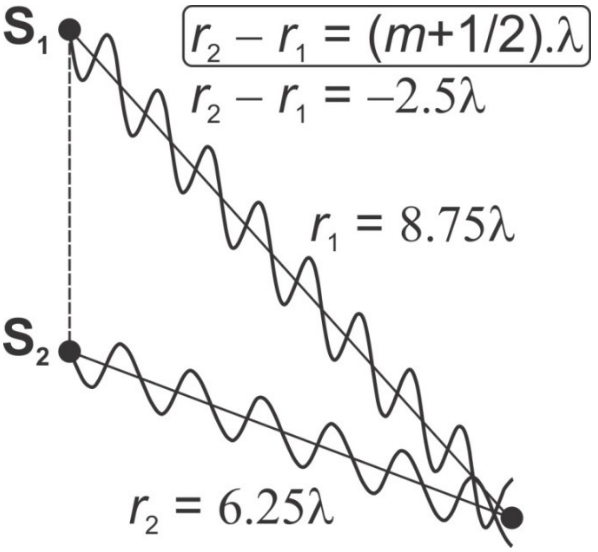

Figure 2.b: Destructive interference.

For there to be constructive interference at a point, the difference between the trajectories: $r_2 - r_1$ for two sources it must be a multiple of the wavelength: λ. Hence, $r_2 - r_1 = m.\lambda \quad (m = 0, \pm 1, \pm 2, \pm 3, \dots)$ (Constructive interference, sources are said to be in phase).

For there to be destructive interference, the condition is:

$$r_2 - r_1 = \left(m + \frac{1}{2}\right).\lambda \qquad (m = 0, \pm 1, \pm 2, \pm 3, \dots)$$

(sources are said to be in phase).

From an energy point of view, all the interference does is to “channel” the energy flow so that it is either a maximum or a minimum.

$$\left.\begin{array}{l}\lambda=\frac{h.c}{E_\lambda}\\ r=c.t\end{array}\right\} c.t_2-c.t_1 \propto m.\frac{h.c}{E_\lambda} \Rightarrow c\Delta t \propto \frac{h.c}{E_\lambda} \Rightarrow \Delta t \propto \frac{h}{E_\lambda}$$

The Δt value is the electromagnetic phase shift.

Table 1: Constructive and destructive interference.

Constructive interference	Destructive interference
$r_2 - r_1 = m.\lambda$	$r_2 - r_1 = \left(m + \frac{1}{2}\right).\lambda$
$\Delta t = m.\frac{h}{E_\lambda}$	$\Delta t = \left(m + \frac{1}{2}\right).\frac{h}{E_\lambda}$

Double slit

Young's experiment demonstrates interference from light passing through two slits. A pattern of bright and dark areas appears on the screen.

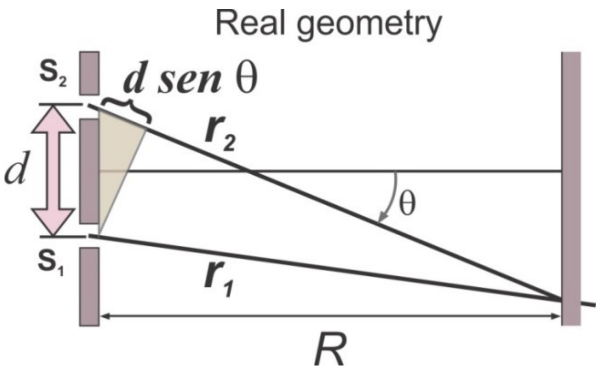

Figure 3: Double slit. *In real situation the distance* R *to the screen is much greater than the distance* d *between the slots.*

The light from S_1 and S_2 hits the screen, generating an interference pattern. It will glow with maximum intensity at P, when light waves interfere constructively, and dark where interference is destructive.

The distance R is large compared to the distance d, that the lines from S_1 and S_2 to P are almost parallel (figure 4).

Hence, the difference in the length of the paths is given by: $r_2 - r_1 = d.\sin\theta$.

Taking into account $c\Delta t \propto \frac{h.c}{E_\lambda}$, then, $c.\Delta t = d.\sin\theta \Rightarrow \Delta t = \frac{d}{c}.\sin\theta$.

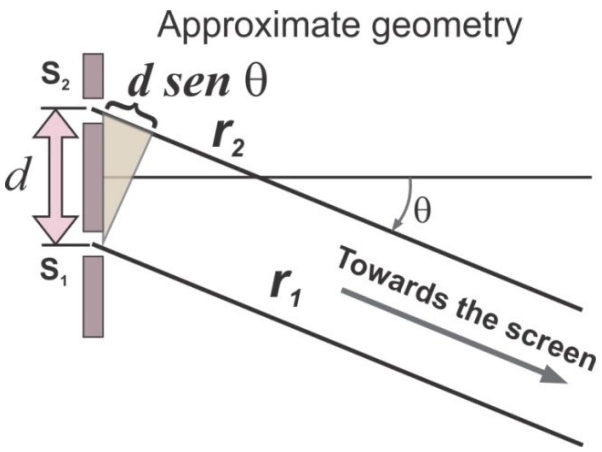

Figure 4: Double slit. *The rays can be considered to be parallel. In such a case, the difference in the length of their paths is:* $r_2 - r_1 = d\ sen\theta$.

Table 2: Constructive and destructive interference.

Constructive interference	Destructive interference
$r_2 - r_1 = m.\lambda = d.\sin\theta$	$r_2 - r_1 = \left(m + \frac{1}{2}\right).\lambda$
$\Delta t = m.\frac{h}{E_\lambda} = \frac{d}{c}.\sin\theta$	$\Delta t = \left(m + \frac{1}{2}\right).\frac{h}{E_\lambda}$ $= \frac{d}{c}.\sin\theta$

Electromagnetic plane waves

The properties of electromagnetic waves can be deduced from Maxwell's equations. It is assumed that the vectors electric field (E) and magnetic field (B) have a specific behavior in space-time, which is consistent with Maxwell's equations [7].

The electromagnetic wave will be assumed to be a plane wave and to be linearly polarized.

Maxwell's equations in a vacuum ($j = 0$, $\rho = 0$).

Assuming:

$E = (0,\ E,\ O)$
$B = (0,\ 0,\ B)$
$\nabla.E = \frac{\rho}{\varepsilon_0} = 0$ Gauss law

$$\frac{\partial E_x}{\partial x}+\frac{\partial E_y}{\partial y}+\frac{\partial E_z}{\partial z}=0\Rightarrow\frac{\partial E}{\partial y}=0\therefore E\neq E_{(y)}$$

$$\nabla.B=0$$

$$\frac{\partial B}{\partial z}=0\therefore B\neq B_{(z)}$$

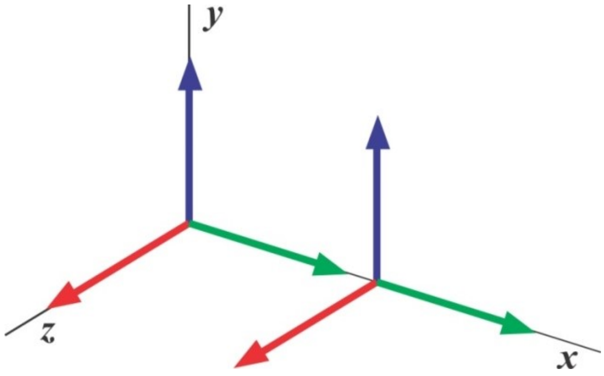

Figure 5: Planar electromagnetic wave.

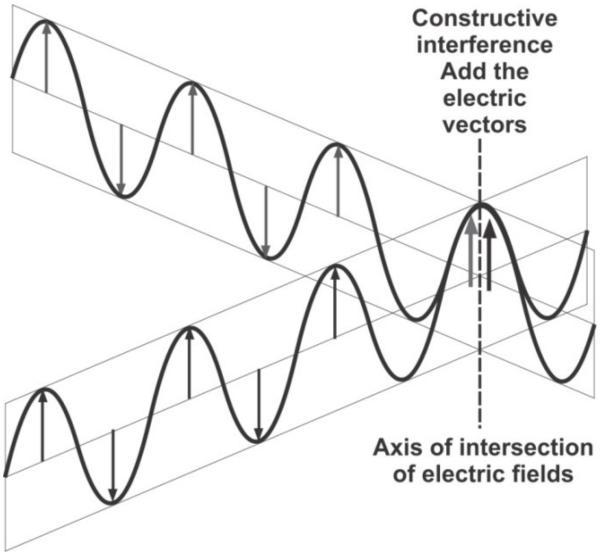

Figure 6: Constructive interference. *The electric vectors add up on the axis of intersection.*

The simplest planar wave solution is a sinusoidal one, for which the amplitudes of E and B vary with x and t according to the following expressions:

$$E=E_{max}\,sen\,(kx-\omega t)$$
$$B=B_{max}\,sen\,(kx-\omega t)$$

Where $k=\frac{2\pi}{\lambda};\ \omega=2\pi v;\ \frac{\omega}{k}=\lambda.v=c$

$$\frac{\partial E}{\partial x}=-\frac{\partial B}{\partial t}$$

$$\frac{E_{max}}{B_{max}}=c=\frac{E}{B}$$

$$\frac{\omega}{k}=\frac{2\pi v}{2\pi/\lambda}=\lambda.v=c$$

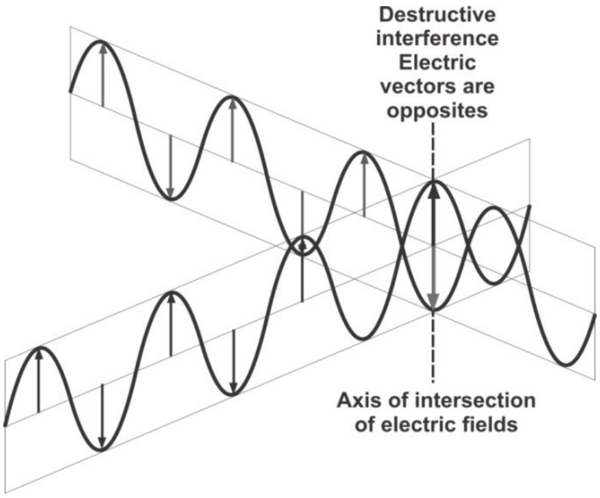

Figure 7: Destructive interference.

Quantum entanglement generation

Analysis of Fraunhofer [8] single slit diffraction to a narrower and wider slit results in an evolving curvature. Thus, shows that the diffracted light manifests the presence of an angular momentum. Consequently, allows the light to converge into the emerging space-time.

The expression $\Delta t=\frac{d}{c}\sin\theta$ corresponds to $\frac{d}{c}$ in where "d" is understood to represent: λ, the light wavelength since at shorter wavelength the higher energy. By narrowing the slit, the blue light responds in a photon train emerging with a dispersion angle those results in a wider band.

A pair of entangled photons integrates the fields [9], maximizing the energy density, with a minimum total angular momentum, operating as a resonance box. Decoherence implies the release of entropy.

The orthogonal condition of the entangled photon fields [10] [11] allows an internal resonance between spins. The coupling of vector fields is unstable and hides a tendency for decoherence [12].

The entanglement manifests a joint moment in a very small space: $10^{-9}cm$. The energy vs. time uncertainty of a system of two coherent photons results in a structure with resonance. This uncertainty could manifest itself in the fluctuating relationship between electric vs. magnetic fields.

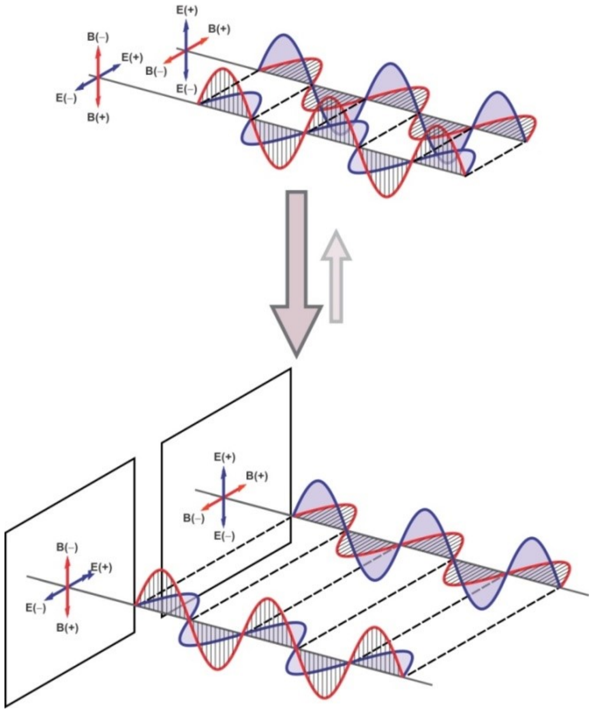

Figure 8: Quantum entanglement and photon coherence.

Quantum entanglement allows Planck bosons [13] to emerge with the same quantum state, giving homogeneity and synchronization throughout the stages of force separation. The dissipative evolution of bosons manifests cause and effect properties operating as a space-time continuum. In which, the energy decreases in frequency in a coherent state that gives homogeneity and at a low entropy rate. The system is not chaotic but self-regulating. Thus, the entropy rate ΔS [14] per time rate Δt, that is, $\frac{\Delta S}{\Delta t}$ for a self-regulating universe, it maintains a much slower rate than for a universe with many degrees of freedom [15] [16] [17].

Heisenberg's uncertainty principle

The "two-photon" nature of the parametric down-conversion is due to the entanglement of the two photons. Two-photon coherence and two-photon entanglement are interrelated concepts. Two-photon entanglement in a given degree of freedom implies two-photon coherence in the corresponding domain. Two-photon interference experiments allow two-photon entanglement [18] [19] [20].

Werner Heisenberg's uncertainty principle states that it is not possible to know position and moment with precision simultaneously: $\Delta x\,\Delta p > \frac{\hbar}{2}$ and neither can energy and time: $\Delta E\,\Delta t > \frac{\hbar}{2}$. This principle can be applied to interference and quantum entanglement.

For two entangled photons: $\Delta(2E)\,\frac{\Delta t}{2} > \frac{\hbar}{2}$, the Δt (uncertainty time) would decrease, which implies that for high frequency photons, Δt would be smaller and the location would decrease according to the expression: $\frac{\Delta x}{2}\ \Delta(2p) > \frac{\hbar}{2}$.

In quantum entanglement each photon is close enough to apply the uncertainty principle as a whole [21] [22]. This contraction of space-time imposes that the electric fields are arranged orthogonally, with the lower configuration of the energy and an increase in the density and mutually add their energetic fluidity. Thermodynamically the entangled system is subject to statistical parameters that force it to decoherent by the flow from a higher to a lower density.

The relationship between moment (p) and total angular momentum (L) [23] [24] allows an alternative expression. Thus, $\Delta p = \frac{\Delta L}{r}$ and $\Delta x = \Delta\phi\, r$, where ϕ is the angle in radians and x is a measure of the curvature or circumference of a circle, and therefore, $\Delta L\,\Delta\phi\ \geq \frac{h}{4\pi}$. The latter shows the uncertainty between angular momentum (L) vs angular position (ϕ).

The total angular momentum of the system of two entangled photons would be composed mainly by the sum of their spins $L = s_1 + s_2 = 2s$. Therefore $\Delta(s_1 + s_2)\,\Delta\phi\ \geq \frac{h}{4\pi} \Rightarrow \Delta(2s_1)\frac{\Delta\phi}{2}\ \geq \frac{h}{4\pi}$. On the other hand, in a coherent photon system $\Delta(s_1)\,\Delta\phi\ \geq \frac{h}{4\pi}$. This allows us to conclude that $\Delta x = \frac{\Delta\phi}{2}\,r$, and therefore explains the space-time contraction of entangled photons [25].

The value of the total angular momentum of the system of two entangled photons would be less than that of a coherent photon. Therefore, due to the uncertainty principle, the dimension of the entanglement is less than the coherence.

In the interference of two photons, the superposition allows locating the position, but due to the uncertainty principle, the moment of the system cannot be known. This may have implications for the quantum entanglement of two photons. The state of the entangled pair is precisely known but the individual quantum state of each one cannot be known simultaneously. Therefore, it produces a zone of probability and superposition for the electric field to operate, which gives it a dynamic or plasticity of energetic configuration.

Coherence time

In the electromagnetic wave, the coherence time $(\tau\!: tau)$ is the time it takes to be considered coherent [26] [27], which means that its phase (T period) is predictable. Is calculated by dividing the coherence length (is the propagation distance over which a coherent wave maintains a specified degree of coherence.) by the phase velocity of light (is the rate at which the wave propagates in some medium), approach: $\tau = \frac{1}{\Delta\nu} \approx \frac{\lambda^2}{c\Delta\lambda}$.

Where λ is the central wavelength of the source, $\Delta\lambda$ is the spectral width of the source in frequency units: $\Delta\nu$.

A single mode fiber laser has a linewidth of a few kHz, corresponding to a coherence time of a few hundred microseconds. Hydrogen masers have linewidth around 1 Hz, corresponding to a coherence time of one second. Their coherence length corresponds to the distance from the Earth to the Moon.

For long distance transmission, the coherence time can be reduced by scattering, spreading and diffraction.

Temporal coherence is the measure of the average correlation between the value of a wave and its delayed by τ, between two instants, and shows how monochromatic a source is. Thus, it characterizes how well a wave can interfere with itself at a different time.

The coherence length (L_c) is defined as the distance the wave travels in time (τ_c). At a delay of $\tau = 0$ the degree of coherence is perfect, whereas it drops significantly as the delay phases: $\tau = \tau_c$.

Schrödinger's Box

In terms of the hypothesis of De Broglie [28] all mass *m*, has associate a wavelength (λ), by the equation $mv = \frac{2\pi\hbar}{\lambda} \vee mv = \frac{h}{\lambda}$. Consequently this relationship introduce in the expression [29].

1st Evaluation

$$\sqrt{\frac{\hbar c^5}{G}} = \sqrt{(mv)^2c^2 + (m)^2c^4} = \gamma \times mc^2 \Rightarrow$$

$$\sqrt{\frac{\hbar c^5}{G}} = mc\sqrt{v^2 + c^2}$$

$$\sqrt{\frac{\hbar c^5}{G}} = \frac{2\pi\hbar c}{\lambda}\frac{\sqrt{v^2+c^2}}{v}$$

Clearing v it is obtained

$$v = \frac{2\pi c\sqrt{G\hbar}}{\sqrt{c^3\lambda^2 - 4\pi^2 G\hbar}}$$

Fulfilling the condition:

$$c^3\lambda^2 - 4\pi^2 G\hbar > 0 \;\therefore\; \lambda > 2\pi\sqrt{\frac{G\hbar}{c^3}} \;\Rightarrow\; \lambda > 2\pi \times l_P$$

The formula shows the relationship between diameter of the particle and the corresponding wavelength.

2nd Evaluation

$$E_P = \sqrt{(mv)^2c^2 + (m)^2c^4} = \gamma \times mc^2$$

$$E_P = mc\sqrt{v^2 + c^2}$$

$$E_P = \frac{hc}{\lambda}\frac{\sqrt{v^2+c^2}}{v} \text{ Where: } v = \frac{hc^2}{\sqrt{E_P^2\lambda^2 - c^2h^2}}$$

It must fulfill the following thing:

$$E^2\lambda^2 - c^2h^2 > 0 \therefore \lambda > \frac{ch}{E_P}$$

Numerically

$$\lambda > \frac{2.9979 \times \frac{10^{10} cm}{s} \times 4.1357 \times 10^{-21} MeV.s}{1.221 \times 10^{22} MeV}$$

$$\lambda > 1.015 \times 10^{-32} cm$$

Quantum parameterization of the Relativistic mass variation by means of the Schrödinger's box

The relativistic treatment can be homologated to the quantum one, by assuming that an electron inside the S-box, relate its spatial coordinates to the increase of kinetic energy. Thus, when apply a force able to re-dimension the box, also re-dimensions the electron. Thus, transformation of kinetic energy into mass and contraction width, by means of the γ-coefficient of relativistic dilation: $m = \gamma \times m_0 \;\wedge\; l = \frac{l_0}{\gamma}$

Lorentz factor: $\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$ [30]

Starting from this relativistic conjecture, it was quantum-assayed the particle's space-time locus as a function of the absorption of energy dimensioned by the γ parameter.

Within the box the particle has the energy quantified in levels n, where width length of the box "a": $E_n = \frac{n^2h^2}{8ma^2}$. Assuming, that "$a$" equals the diameter of the particle $\emptyset$, then: $E_n = \frac{n^2h^2}{8m\emptyset^2}$. Applying a work in the x-axis direction which and the relativistic considerations, it is obtained: $E_n = \frac{n^2h^2}{8(\gamma m_0)\left(\frac{\emptyset}{\gamma}\right)^2} \therefore E_n = \gamma\frac{n^2h^2}{8m_0\emptyset^2}$, [31] $[E] = \frac{J^2s^2}{kg \times m^2}$.

For $\gamma = 1$, electron mass at rest: $m = 9.1 \times 10^{-31} kg$, Planck constant: $h = 6.626 \times 10^{-34}\, J.s$, a Compton wavelength: $\lambda = \frac{h}{mc}$ for the electron: $\lambda = 2.426 \times 10^{-12} m$, is obtained: $E_n = 1.23864 \times n^2$.

Table 3: Wavelength of the visible spectrum.

Visible spectrum	λ [nm]
Red	618-780
Orange	581-618
Yellow	570-581
Green	497-570
Cyan	476-497
Blue	427-476
Violet	380-427

The visible spectrum is the region of the electromagnetic spectrum that the human eye is capable of perceiving. Light visible to the typical human eye will respond to wavelengths from 380 to 750 nm [32].

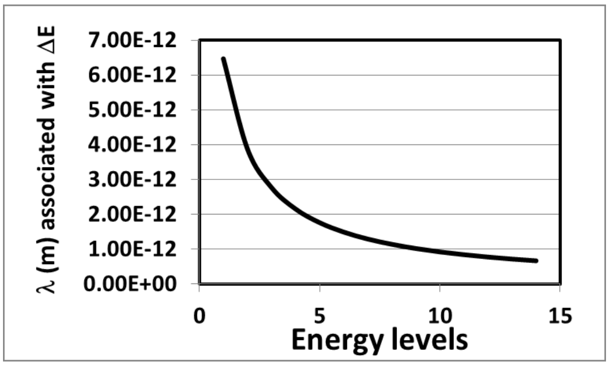

Figure 9: λ associated with the energy jump within the Schrödinger box [33].

The dimensionality of the electron by the Schrödinger box, could describe the phenomenon: "Forbidden light", where light pulses at frequencies of terahertz (billions of pulses per second) to accelerate electrons known as Cooper pairs [34].

The light emitted by the accelerated electron pairs, they show "second harmonic light emissions" or a light at twice the incoming frequency used to accelerate the electrons [35]. Find our interpretation using the Cooper pair at high energy.

It can be interpreted that the incident photons, by accommodating their energy as inertial mass within the Cooper pair, with increasing energy density, contract the space-time of the electron. Since it cannot accommodate energy, it can only emit a photon with double frequency.

From the perspective of Schrödinger's box, the interference would be an energy level jump with subsequent emission of two photons. Wavelengths of photons that can enter an electron sized according to Compton in a Schrödinger box. This is the only length scale that can be associated with such particles, which determines the scale of the quantum effects and is inversely proportional to the mass of the particles. But even that scale cannot be defined before $10^{-11} s$ after the big bang. This is logical, since the electroweak force separates at $10^{-10} s$.

A fundamental aspect of quantum mechanics is the wave nature of matter. Thus, the electrical charges that make up matter behave, when they vibrate, like tiny antennas that emit electromagnetic waves, showing the operation of a microscopic-quantum level. She might remedy the singularities of classical theory by replacing what was once a point with regions of finite size, and would banish the error of dividing by zero.

Table 4: Energy level jump in an electron dimensioned by the Schrödinger box.

Schrödinger box level	Energy	Energy change: $\Delta E = \lvert E_1 - E_2 \rvert$	Associated λ in meters	Associated λ in nano-meters
	(E) [J]	(ΔE) [J]	$[m]$	$[nm]$
1	1,024E-14			
2	4,095E-14	3,071E-14	6,468E-12	0,00647
3	9,213E-14	5,118E-14	3,881E-12	0,00388
4	1,638E-13	7,166E-14	2,772E-12	0,00277
5	2,559E-13	9,213E-14	2,156E-12	0,00216
6	3,685E-13	1,126E-13	1,764E-12	0,00176
7	5,016E-13	1,331E-13	1,493E-12	0,00149
8	6,551E-13	1,536E-13	1,294E-12	0,00129
9	8,292E-13	1,740E-13	1,141E-12	0,00114
10	1,024E-12	1,945E-13	1,021E-12	0,00102
11	1,239E-12	2,150E-13	9,240E-13	0,00092
12	1,474E-12	2,354E-13	8,437E-13	0,00084
13	1,730E-12	2,559E-13	7,762E-13	0,00078
14	2,006E-12	2,764E-13	7,187E-13	0,00072
15	2,303E-12	2,969E-13	6,691E-13	0,00067

A light wave is the combination of an electric field and a magnetic field perpendicular to each other. Polarization is defined on the direction of the electric field, imposing directionality and time. Therefore, it breaks the symmetry and it would be necessary so that a remnant of matter remains in the particle-antiparticle annihilation.

This behavior is caused by the quantum superposition effect. It allows a particle to be simultaneously a particle and its own antiparticle. What Oxford researchers have observed for the first time is that charm mesons oscillate between the two states. The meson does not have the same mass when it adopts the particle state and the antiparticle state. The difference is very small $(10^{-38}\ g)$ [36]. This means that they can adopt the particle form, jump to the antiparticle state and regain the particle state, spontaneously.

Quantum entropy

The simple linear relation between S and k given by eq.: $S = \frac{4}{3}\ k\ A_T$ and supports the postulate that the statistical entropy of a collection of photons developed in statistical mechanics arises from an "entropy quantum." In statistical physics, entropy is often related to the notion of disorder. From this perspective, photons encode quanta of disorder from emitters and transport disorder to absorbers. Furthermore, the minimum amount of disorder transport is of the order of k.

The theory provides an appealing single photon analog to the well-known Bose–Einstein formula for a system of photons in a physical enclosure of volume V. In both cases, it is found that: $S = \left(\frac{4}{3}\right) aT^3V \wedge U = aT^4V \wedge P = \frac{1}{3}aT^4 = \frac{1}{3}\frac{U}{V}$.

For the single photon case: $a = \frac{A_T^4}{A_V}\frac{k^4}{(hc)^3}$ This compares with the Bose–Einstein coefficient $a_{BE} = \frac{8\pi^5}{15}\frac{k^4}{(hc)^3}$

K_{PB} is fundamental since it arises in cosmology, quantum mechanics, and black body radiation. Moreover, it connects statistical physics with classical thermodynamics and deterministic physics exemplified by the fundamental Planck dimensions: L_P, T_P, and M_P.

For photon systems, the second law does not impose the rigid constraint of parallel transport of energy and entropy that it does for classical systems in thermal contact. This example provides a photon basis for the distinction between adiabatic and isentropic processes that applies to classical investigations.

Two coherent photons each carry the same information. Two entangled photons are orthogonal and each carries half the information, therefore they generate half the entropy of classical coherence.

The entropy of the squeezed quantum state is zero, because it is a pure state. Due to the interaction with other degrees of freedom, however, the fluctuations have to be described by a density matrix ρ. The relevant quantity is then the von Neumann entropy [37] [38] [39]: $S = -\mathrm{Tr}(\rho \ln \rho)$.

Photon entropy

The entropy of entanglement is the Von Neumann entropy of the reduced density matrix for any of the subsystems. If it is non-zero, the subsystem is in a mixed state, it indicates the two subsystems are entangled [40].

They developed an expression for the radiation density and concluded, “The entropy per photon is therefore equal to $k\,(1 - \ln f_r)$.” Here f_r is the photon distribution function and k is Boltzmann's constant.

The analysis provides a classical explanation for the minimum value of entropy of an isolated thermodynamic system, whose value is of the order of k and is carried by photons. This intrinsic photon entropy is independent of photon wavelength. This agrees precisely with recent results from black hole thermodynamics [41] [42] [43], when the Schwarzschild radius and the Planck length are comparable [44].

The emergent space as a function of chronological time responds to the evolution of the Hubble constant

The Hubble-Lemaître law can be formulated as: $z = \frac{H_0}{c} D$, where z is the redshift, D the comoving distance to the galaxy, H_0 the Hubble constant and c the velocity of light.

The expansion rate of the universe is not constant, so the law is valid for local cosmological distances, with small values of redshift $z < 0.1$, where it can be approximated: $H_{(z)} \approx H_{(z<0.1)} \equiv H_0$.

The time-dependent Hubble parameter is defined as: $H_{(t)} = \frac{\dot{a}_{(t)}}{a_{(t)}}$, where $a_{(t)}$ is the expansion parameter. It is also stated that: $\frac{dH}{dt} = -H^2\,(1+q)$, where q is the dimensionless deceleration parameter defined as $q = -\frac{\ddot{a}\,a}{\dot{a}^2}$.

All postulated mass-energy forms produce a deceleration parameter: $q \geq -1$. Supernova observations reveal a value $q \sim -0{,}6 \pm 0{,}2$, evidence for cosmic acceleration, which has subsequently grown stronger.

As the cosmological constant becomes more and more dominant over matter, H_0 will tend to a constant value of 57 km/s/Mpc, and the scale factor of the universe will operate mostly on the *voids* so that they grow exponentially, disengaging from the matter.

Is assumed the current value of the Hubble constant: $71\ km.s^{-1}.Mpc^{-1}$. The inverse of the constant allows us to calculate the age of the universe: $13.7 \times 10^9\ ly\ (4.34 \times 10^{17} s)$.

The Hubble constant was primarily very large and decreases with time. The PDC (parametric down-conversion) shows that split and elongation of energy of particles doubles the distances and decreases by half the frequency, as a function of Planck bosons follows this pattern restricted by c [45].

This would be consistent with the polarization of light, which is defined in the direction in which the electric field oscillates. An absorber polarizer turned at any angle will always transmit half the incident intensity, when averaged over time.

The dissipation of Planck bosons stretches space as a function of enthalpy, preserving homogeneous quantum states. Quantum entropy of one Planck boson eventually accumulates statistically as global cosmological entropy.

Space does not impose cause and effect relationships. This relationship that one event (cause) necessarily implies another (effect), its separation is always based on time, which delimits chronologies.

The space created by the dissipation of the Planck bosons in the PDC function imposes a temporal arrow. This would explain the primordial homogeneity.

The velocity of light relates all Planck units and is therefore a constant. Therefore, inflation cannot be derived from the time delimited by the thermodynamics of c. Hence, it depends on spatial changes associated with cause-effect that evolves as a function of PDC.

The emergence of space as a function of chronological time responds to the evolution of the Hubble constant.

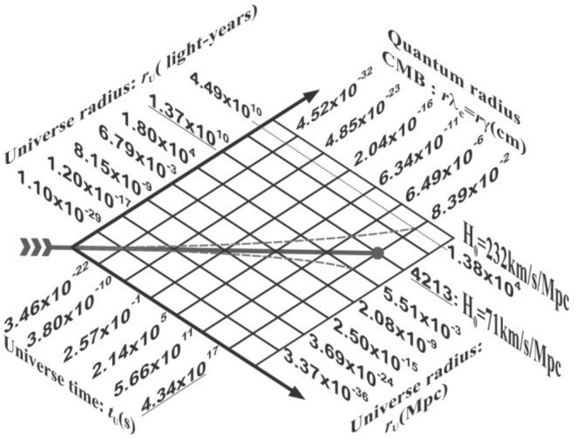

Figure 10: The relationship between recession velocities vs the radius and time of the universe. *For present time* $4.34\times10^{17}s$ *solving:* $H_0 \times r = v$. [46].

Hubble's law for a homogeneous expanding universe, in 3-dimensional cartesian/newtonian coordinate, is considered as a metric space, and isotropic (properties do not vary with location or direction). However, $H_{(t)}$ it changes based on the "*lookback on time*" finding.

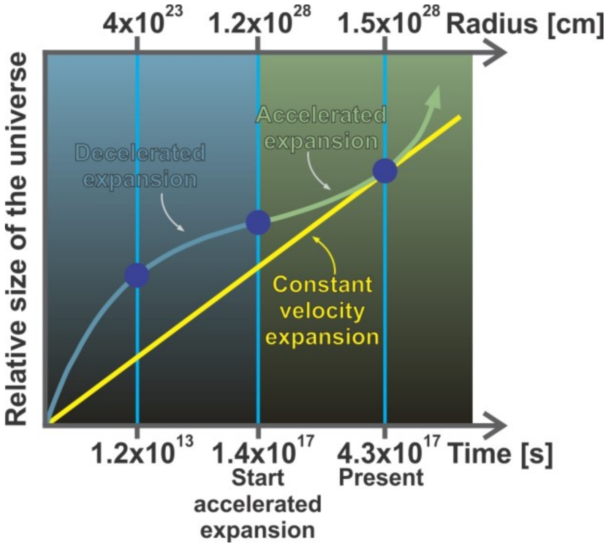

Figure 11: Stages of expansion. *From deceleration to current acceleration.*

When the recession velocity of the galaxies, makes the particles approach c, the moment that transforms the energy into inertial mass cannot be absorbed. Therefore, it increases the emission of photon radiation with transfer from moment to angular momentum in the form of a spin.

Systems organized in function of frequency

The universe is considered as the evolution of a self-organized system, due to the dissipative function of the entangled Planck bosons. In each stage the energy is configured with decreasing density and frequency.

The propagation of the primordial gravitational waves produces in the plasma density fluctuations that produce sound and the seeds for the eventual formation of galaxies. In the meantime, the remaining energy of the gravitational waves, when the plasma oscillates, emits radiation that manifests this effect by manifesting polarization.

Regarding the polarization of gravitational waves, unlike electromagnetic waves, which admit multiple polarizations, gravitational waves admit only two types of independent polarization. In Einstein's General Theory of Relativity, gravitational waves only admit plus polarization and cross polarization and the angle between them is $\pi/4$ [47].

At the cosmological level, the decrease in frequency is associated (coupled) to expansion and this to the increase in dimensionality as a function of PDC as an inverse of the so-called Hubble constant, which, when decreasing, reflects the chronology.

At the microscopic level, the characterization of the macroscopic Hubble relationship can be linked to an entanglement-regulated decrease in the primordial density of Planck bosons. It is associated with the decrease in frequency in the wave function (division, decrease in frequency: ν and λ-elongation of photons).

It also responds to PDC. As the energy density decreases due to space-time expansion, it maintains the microscopic decrease in frequency in Planck relation: $2^n \times 5.4 \times 10^{-44} s, \quad n = 1, 2, 3, \ldots$ the location of microscopic energy density as a function of a single Planck boson.

Therefore, time is conjugated with the same vectority in cosmology as in quantum mechanics, when the PDC relation is used to explain the decrease in frequency, which affects the total of Planck bosons [48] [49].

Applying the thermodynamics of a self-contained universe only allows internal location of entropy by increasing the volume of the *voids*.

It can be explained by the proposition that in these the expansion responds to the distension of the frequency, elongation of photons as a function of the decrease of the fourth power of the temperature (T) [50].

The CMB spectrum is detected as a wavelength of: $5.27 \times 10^{-1} cm$ at $T = 2.725K$ emitted at $T = 3{,}000K$. Therefore, PDC allows the photons to multiply by 2 and the volume to grow by 16.

The present density is 411 photons per cm^3 and corresponds to a total of 3.78×10^{87} photons in the universe [51]. This number multiplied by the Compton volume of the photon corresponds to the present volume of causality of the present universe. By applying PDC to the Surface of Last Scattering Era the photons were elongated approximately 1,000 times.

Throughout the dimensioned chronology looking back in time (lookback on time), the harmonics of decreasing frequency of baryonic acoustic waves appear. These do not propagate in a vacuum like electromagnetic waves, but they are associated with chronology.

The hydrogen line

The 21 cm hydrogen line consists of the spectral line of electromagnetic radiation that is created by a change in the energy state of neutral hydrogen atoms.

The conversion of the state of the spin breaks the local containment by delocalization of the electron between two positions, allows absorbing kinetic energy and emitting photons.

In a pair of entangled photons, the proximity of the electric fields allows a resonance of superposition of energies, reducing the volume of entanglement due to the uncertainty principle.

The dynamics of space-time is present in the spin-geometry relationships [52], which manifests itself as a tension between spins, generating curvature, geometric information that changes, assigning differentiable information for each particle, but shared by the pair [53] [54] [55].

The pair quantum interconnects space and time, allowing the classic emergent space-time of quantum entanglement, through the process of decoherence.

Cosmologically, a coherent process gives the baryons confined in the *voids* time to be expelled, and to join the stellar accretion discs. *Voids* can be treated as a thermodynamic system that manifests surface tension [56].

Thermodynamics linked to the Hubble constant allows identical particles of high coherence, with a dissipative direction due to decreasing energy density and increasing entropy.

Hubble's Law would allow the mass to absorb energy, maintaining the flatness of the expansion. This energy addition would increase the gravitational attraction.

Linear momentum and angular momentum, which do not have a maximum limit value, require reinterpreting the internal properties of energy and spin, in their different configuration contexts, either as particles, photons, hydrogen gas or galaxies.

These advances can generate a cosmological model that describes the evolution of entangled primordial Planck bosons, as an internally open and dissipative system.

Conclusions

A re-interpretation of duality should be conditioned by the value of the wave frequency, defining a space of localization, less and less for high energies. Thus, allows a blue photon to penetrate the electron, changing its inertial mass and momentum, but the size of red photon exceeds the Compton wavelength of the electron.

The resting mass could be modified as shown by electron microscopy, with by magnetic compression is capable to generate greater resolution, involving magnification of electron momentum by the contraction of its size, phenomenon does not correspond to a particle role.

The conformation of the electromagnetic space of the electron allows only high-frequency photons to be located in it. This electromagnetic response of the electron gives it quantum plasticity through the internal energy levels, of the orbital transitions between an internal dynamic position to an external one, and which results in the emission of photons.

Quantum entanglement allows us to examine very successful experimental approaches, from which the nature of the superposition between two photons in the same state can be deduced, and the space-time of coherence vs. decoherence state, determining the correspondence wave structure between electric and magnetic field.

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