PDC-dependent sequence of CMB divisions analyzed as a Schrödinger's energy-box

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Abstract

Simulations relating the Big-Bang-chronology to primordial quanta incrementing in number and elongating into CMB, suggested a quantum dependent-expansion based in parametric down-conversion (PDC). The PDC-dependent increase in the number of photons, by uniformly emerging and aggregating, when measure along the cosmos radius, yields per Mpc the Hubble's constant value. Seeking to elucidate the correspondence between quantum-microscopic and macroscopic scalar-levels, their interaction was idealized by assuming that a quantum of space-time could be represented as an adiabatic Schrödinger's box. Conjugation of the time-independent equation allowed a 3D-visual description of the intra- or inter-relationship between energy and space for a PDC-turnover. A chain of PDC turnover events, by conforming steps of lower and lower dissipative potential, operate a quasi-open thermodynamic system. Hence, allowing that at each of the sequence of PDC turnovers, the product, two photons of twice wavelength, do not accumulate, because in turn these become substrates for subsequent turnovers. The schematic representation of this process in a Schrödinger's box, allowed predicting a photon-division transition as a two-peak wave. To analyze a theoretical bridge between gravitational independent sequences of PDC process, that by incrementing photon number and by their self-dimensioning expansion shows best-fit with the data obtain by astronomical observation. It is widely accepted that the increment in the universe volume could be related to the energy axis from Planck limit to present CMB. This has been idealized as a dissipative potential, of frequency decreasing in function of expanding Schrödinger's boxes. This could become integrated as a dissipative potential, conforming a continuum of decreasing frequency density.

Introduction

Quantum theory [1] usually described particles as points within external coordinates of the space-time, without assigning internal parameters that could be dimensioning as a function of the evolving cosmos. String theories [2] as a solution develop multi-dimensional descriptions using lines in place of points to avoid infinites.

In order to restrict the number of dimensions, to the ones known, the quantum parameters of cosmic evolution were described as departing from the progress of a quantum structuring inflation in the energy-space-time [3, 4, 5]. Simulation based in this model integrates the observable dimensions of the cosmos, as the resultants of the dynamics of internal quantum parameters [6, 7, 8, 9, 10]. The open-like thermodynamics [11] of this quantum-structured universe could therefore show properties of a continuum [12, 13, 14].

Simulations relating the Big-Bang [15] energy chronology [16, 17, 18, 19, 20] to CMB [21] elongation, suggested a self-contained cosmos, emerging with a quantum structure according to $\sqrt{2\pi\hbar \times G/c^3} = 4\times10^{-33} cm$ or/and $l_{Pl} = \sqrt{\hbar \times G/c^3} = 1.6\times10^{-33} cm$, delimiting a causality horizon.

Primordial energy was undergoing quantification and localization by integrating the space-time of Planck particles. The causality delimiting velocity of light (c) was overpass during inflation [22, 23, 24, 25, 26], presumably because simultaneously and cooperatively was increasing the number of Planck particles (γ_P) from an initial one to the number required to constitute critical energy.

After completion of the universe aggregate quantum structure, by the lack of further addition of γ_P, enthalpy ceases to increase. Expansion thereafter becomes based in single parameter of energy density decrease as a function of cosmic time. This relationship allowed to obtain thermodynamic [11] coordinates for energy-space-time. Evaluated from a cosmos structured by the aggregate of 1.5×10^{60} Planck particles reaching by PDC [27] the present photon number (nγ) of 3.8×10^{87} of actual CMB [21, 28, 29, 30].

This mathematical treatment shows a geometrical increment of 10^{31} from the Planck length (1.6×10^{-33} cm) to the mean value of the photon-radius [31] of residual CMB spectrum. This value 8.38×10^{-2} cm has a 3D a correspondence of 2.5×10^{-3} cm^3 that multiplied by 3.8×10^{87} yield the actual volume of a universe 9×10^{84} cm^3 of radius 1.3×10^{28} cm.

However, it could be assumed that PDC operates to duplicate photons and halve their energy at all corresponding wavelengths of the CMB-spectrum.

This would allow a range of intermediate values for photon-radius, in such a manner that the detection of CMB as a spectrum turns difficult the calculation for a more precise evaluation of the best-fit, between aggregate quanta volume and the universe volume.

Total energy enthalpy plus entropy could be shown constant by describing the increases of entropy [11] as a function of the increases of number photon (nγ) and decrease in energy density. Einstein's model for Planck's law: $\rho_v = 8\pi h v^3/c^3 \times e^{-hv/kT}$ or $\rho_v = 8\pi h/\lambda^3 \times e^{-hv/kT}$, suggested that density of spectral energy could be more schematically treated, as frequency-density. The latter, applied to the universe chronology, was studied because applied to an energy gradient, represents quantum thermodynamic structures perceivable as a continuum.

Results

It could be estimated that the decrease of density frequency (ρ_v), as a function of the decrease between Planck density (1.5×10^{118} MeV/cm^3) and the present universe photon density (1.86×10^{-3} MeV/cm^3), corresponds to an exponential gradient 10^{120} (figure 1). This value corresponds to a slope of 2.1, which indicates a cooperative dependency [32] of the reaction rate from two or more parameters. On the other hand, the increment in the universe radius as a function of time shows slope of 1.

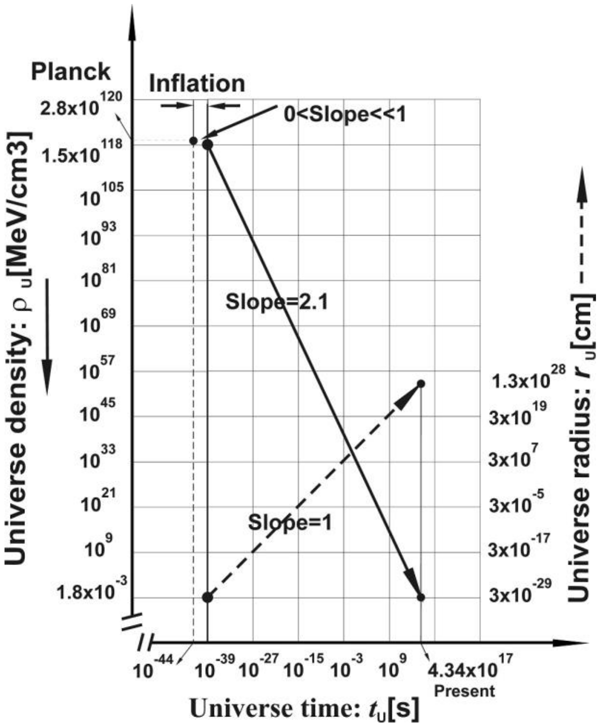

Figure 1: Cooperative parameters. *The energy density decrease rate (log [$\rho_{(t)}$]) as a function of the expanding universe volume, measured in MeV/cm^3, was plotted on the y-axis. The x-axis (log [t]) shows the chronology from Planck energy limit to present CMB. Simulations to evaluate the rate of quantum-dependent increment of the universe volume were based in the increment and dimensionality of the photon: $n\gamma\times V\gamma$. The Compton localization, $\lambda c = h/2\pi mc$ lead to an equivalence: $\lambda/2\pi = \lambda c = r\gamma$. The PDC-dependent changes in $n\gamma$ were incorporate directly as increment in the universe volume. During inflation the slope of energy density, was much lower than one, because the progress of quantification by incrementing the total energy within the system increases density (ρ), adding as cooperatively negative.*

According to Boltzmann for an x state of a box volume: the constant: $k = 1.38\times10^{-23}$ J/K = 8.614×10^{-11} MeV/K [30] and entropy $\Delta S = k\times\log V$.

A unity of energy density MeV/cm^3 was used as a function of V_U, to assay entropy along the chronology of universe.

S(V), inflation-expansion: Taken in account the Planck or initial to inflation volume:

$$\Delta S_{(V)} = k \times \log \frac{V_U}{V_{Pl}} =$$

$$= k \times \log \frac{9.2 \times 10^{84} cm^3}{1.768 \times 10^{-98} cm^3} = 183k$$

S(V), expansion: However, quantification of the universe energy leads to $n\gamma$=1.51×10^{60} Planck particles which requires the aggregated volume =1.14×10^{-36} cm^3.

$$\Delta S_{(V)} = \frac{\left(3.78 \times 10^{87} - 1.51 \times 10^{60}\right)}{6.023 \times 10^{23}} \times 5.19 \times 10^{13} \frac{\mathrm{MeV}}{\mathrm{K}} \times$$

$$\times \log \frac{9.2 \times 10^{84} cm^3}{1.14 \times 10^{-36} cm^3} = 3.94 \times 10^{79} \frac{\mathrm{MeV}}{\mathrm{K}}$$

PDC at the cosmos level could magnify its entropy impact by the space-time changes incrementing quantum disorder over the E_T.

After having transfer energy for the formation of matter the remaining radiation energy (CMB), equals to 1/20000 of total energy (E_T). Hence, reducing contribution of division-elongation to entropy, generated as a function of expanding vacuum, and the increment in $n\gamma$. The resulting quantum disorder is additional, but could be differentiated and separately calculated.

If the initial energy remained constant, n that could represent the number of photons does need to be included.

The Planck density, ρ_P, evolves as a dissipative function of PDC, incrementing photon number progressively, but each PDC cycle leading to less and less photon energy density, $\rho_{E\gamma} = E_T / V_U = E_\gamma \times \cancel{n\gamma} / V_\gamma \times \cancel{n\gamma} \therefore \rho_{E\gamma} = E_\gamma / V_\gamma$, a quantum relation linking the increment of γ-volume to the V_U chronology.

$$\Delta\rho_U = \frac{E_T}{V_T} = \frac{E_T}{4/3 \times \pi \times (\Delta r_U)^3} = \frac{E_T}{4/3 \times \pi \times c^3 \times (\Delta t_U)^3}$$

$$\Delta\rho_U = \frac{E_T}{V_T} = \frac{E_T}{V_\gamma \times n\gamma} = \frac{E_T}{4/3 \times \pi \times (\Delta r_\gamma)^3 \times n\gamma}$$

S(ρ), inflation:

$$\Delta S = k \times \log \left[\frac{V_1}{V_0} \right] \text{ and } V = \frac{E_T}{\rho_U}$$

$$\Delta S_{INFL} = k \times \log \left[\frac{E_T / \rho_{Ex}}{E_T / \rho_P} \right] = k \times \log \left[\frac{\rho_P}{\rho_{Ex}} \right]$$

$$\Delta S_{INFL} = k \times \log \left[\frac{2.8 \times 10^{120}}{1.5 \times 10^{118}} \right] = k \times \log\left(1.9 \times 10^3\right)$$

S(ρ), inflation-expansion:

$$\Delta S(\rho) = k \times \log \left[\frac{E_T / \rho_{Pr}}{E_T / \rho_P} \right] = k \times \log \left[\frac{\rho_P}{\rho_{Pr}} \right]$$

$$\Delta S(\rho) = k \times \log \left[\frac{2.8 \times 10^{120}}{1.8 \times 10^{-3}} \right] = k \times \log\left(1.6 \times 10^{123}\right)$$

Gravitational entropy S_{grav}=10^{121} would add cooperatively, indicating the requirement to integrate the entropy contribution of different origins. Penrose [19] calculated the entropy of the primordial cosmos to present as 10^{150}.

The increment in entropy measure for energy density decrease shows as cooperative functions between the decreasing λ-energy (elongation) and the increment of the universe volume.

This suggested that expansion may be analyzed by elucidating the integration between two dynamics. The one corresponding to the stretching of the wavelength from primordial to present CMB, a frequency or energy decrease and a 1-directional parameter and its 3D dynamics correspondence within the parameters of the stretching space.

This one could be analyzed according to wave time-independent equation: $\psi_1 = \sqrt{2/L}\, sen(n_1 \pi x/L) + 0 \times i$ (i: imaginary part). This treatment allows idealizing a transition as a succession of wave functions, as contained in Schrödinger's box.

The use of a linear Hermitic operator, $\int_\Omega \Psi_1^* (\hat{A}\Psi_2) d\omega = \int_\Omega (\hat{A}\Psi_1)^* \Psi_2 d\omega$, produces uniform restricted, but continuous functions that could be applied to discrete changes of the energy potential. Thus, allowing idealization of the possible states of quanta aggregating into an expanding space. Sequence of resultants dissipative potential: $\Psi_1 \rightarrow \Psi_2 \rightarrow \Psi_3 \rightarrow \ldots \rightarrow \Psi_n$, with $E_1 > E_2 > E_3 > \ldots > E_n$.

It is inferred, that each of the resultants would contain less and less energy but each step would still be able to maintain the system away from its equilibrium conditions.

Hence, resultants as PDC products reenter as substrate to PDC generating a continuum dissipative potential; interacting as if were within an open thermodynamic system. An undefined pre-causal state of energy-space-time could progress through quantification to a quantum structure self-contained universe, resulting in inflationary structuring of energy.

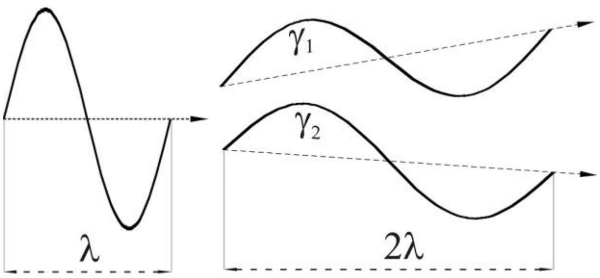

Figure 2: A PDC step idealized as a stretching Schrödinger's box. *The PDC process, assimilated to a gravity-independent spatial increment of a quantum, delimits for each photon a space region (Ω), for its energy splitting transition:* $\lambda \rightarrow$ *(Double*λ *plus double*λ*). Each PDC-like turnover, allows a dissipative chain of stair cased potentials, by reusing the PDC product as the next substrate, and therefore could be integrated as driving an overall cosmic expansion.*

Hermitic Operator

$$\int_\Omega \Psi_1^*(\hat{A}\Psi_2)d\omega = \int_\Omega (\hat{A}\Psi_1)^*\Psi_2 d\omega$$

Derivative of primer Operator $\hat{A} = \dfrac{d}{dx}$; space integral ($\int_\Omega$); $d\omega = d\,x\,d\,y\,d\,z$; Ψ_1 and Ψ_2 delimit functions, uniformly and continuously by extending to all the space an assumed to be convergent; n_1 and n_2 energy levels for interval $0 < x < 2\pi$. The different auto-values are represented as perpendicular (orthogonal), commuting the same auto-function.

Schrödinger wave time independent equation: $\psi_1 = \sqrt{2/\mathrm{L}}\,\mathrm{sen}(\mathrm{n}_1\pi x/\mathrm{L}) + 0 \times i$ (i: imaginary part) $\Rightarrow$ conjugate: $\psi_1^* = \sqrt{2/\mathrm{L}}\,\mathrm{sen}(\mathrm{n}_1\pi x/\mathrm{L}) \therefore$

$$\hat{A} = \frac{d}{dx}\left(\sqrt{2/L}\,sen(n_1\pi x/L)\right) = \sqrt{2}L^{-3/2}\pi n_1 \cos(\pi n_1 x/L)$$

$$(\hat{A}\psi_1)^* = \left[\hat{A}\left(\sqrt{2/L}\,sen(n_1\pi x/L)\right)\right]^*$$

$$(\hat{A}\psi_1)^* = \sqrt{2}L^{-3/2}\pi n_1 \cos(\pi n_1 x/L)$$

$$\psi_2 = \sqrt{2/\mathrm{L}}\,\mathrm{sen}(\mathrm{n}_2\pi x/\mathrm{L}) \Rightarrow$$

$$\hat{A}\psi_2 = \hat{A}\left(\sqrt{2/L}\,sen(n_2\pi x/L)\right)$$

$$\hat{A}\psi_2 = \sqrt{2}L^{-3/2}\pi \times n_2 \cos(\pi n_2 x/L)$$

$$\int_\Omega \Psi_1^*(\hat{A}\Psi_2)d\omega = \int_\Omega \sqrt{2/\mathrm{L}}\,\mathrm{sen}(\mathrm{n}_1\pi x/\mathrm{L})\sqrt{2}\mathrm{L}^{-3/2}\pi\mathrm{n}_2 \cos(\pi\mathrm{n}_2 x/\mathrm{L})d\omega$$

1.

$$\int_\Omega \Psi_1^*(\hat{A}\Psi_2)d\omega = \int_\Omega 2\pi\mathrm{n}_2\mathrm{L}^{-2}\cos(\pi\mathrm{n}_2 x/\mathrm{L})\mathrm{sen}(\pi\mathrm{n}_1 x/\mathrm{L})d\omega$$

$$\int_\Omega \Psi_1^*(\hat{A}\Psi_2)d\omega = \frac{\mathrm{n}_2}{\mathrm{L}}\left(-\frac{\cos(\pi x(\mathrm{n}_1-\mathrm{n}_2)/\mathrm{L})}{\mathrm{n}_1-\mathrm{n}_2} - \frac{\cos(\pi x(\mathrm{n}_1+\mathrm{n}_2)/\mathrm{L})}{\mathrm{n}_1+\mathrm{n}_2}\right)$$

2.

$$\int_\Omega (\hat{A}\Psi_1)^*\Psi_2 d\omega = \int_\Omega 2\pi\mathrm{n}_1\mathrm{L}^{-2}\cos(\pi\mathrm{n}_1 x/\mathrm{L})\mathrm{sen}(\pi\mathrm{n}_2 x/\mathrm{L})d\omega$$

$$\int_\Omega (\hat{A}\Psi_1)^*\Psi_2 d\omega = \frac{\mathrm{n}_1}{\mathrm{L}}\left(-\frac{\cos(\pi x(\mathrm{n}_1-\mathrm{n}_2)/\mathrm{L})}{\mathrm{n}_1-\mathrm{n}_2} - \frac{\cos(\pi x(\mathrm{n}_1+\mathrm{n}_2)/\mathrm{L})}{\mathrm{n}_1+\mathrm{n}_2}\right)$$

Analysis of Hermitic in 2D-Plot

$$\int_\Omega \Psi_1^*(\hat{A}\Psi_2)d\omega = \int_\Omega 2\pi\mathrm{L}^{-2}\mathrm{n}_2\cos(\pi\mathrm{n}_2 x/\mathrm{L})\mathrm{sen}(\mathrm{n}_1\pi x/\mathrm{L})d\omega$$

$$\int_\Omega \Psi_1^*(\hat{A}\Psi_2)d\omega = \frac{\mathrm{n}_2}{\mathrm{L}}\left(-\frac{\cos(\pi x(\mathrm{n}_1-\mathrm{n}_2)/\mathrm{L})}{\mathrm{n}_1-\mathrm{n}_2} - \frac{\cos(\pi x(\mathrm{n}_1+\mathrm{n}_2)/\mathrm{L})}{\mathrm{n}_1+\mathrm{n}_2}\right)$$

$$\int_\Omega \Psi_1^*(\hat{A}\Psi_2)d\omega = \Psi_\alpha + \Psi_\beta$$

$$\Psi_\alpha = \frac{-n_2}{n_1-n_2}\,\frac{\cos[\pi x(n_1-n_2)/L]}{L}\ \text{(Red curve)}$$

$$\Psi_\beta = \frac{-n_2}{n_1+n_2}\,\frac{\cos[\pi x(n_1+n_2)/\mathrm{L}]}{L}\ \text{(Blue curve)}$$

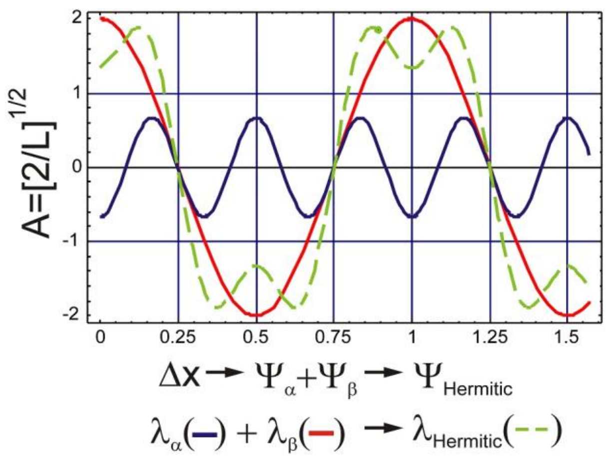

Figure 3: The 2D-dynamics of the PDC process. *$\Psi_{Hermitic}$ represent a re-composition of two wavelengths λ_α of higher energy than λ_β to generate the Hermitic wavelength that may represent an approximation to characterize the transition state like a wave function.*

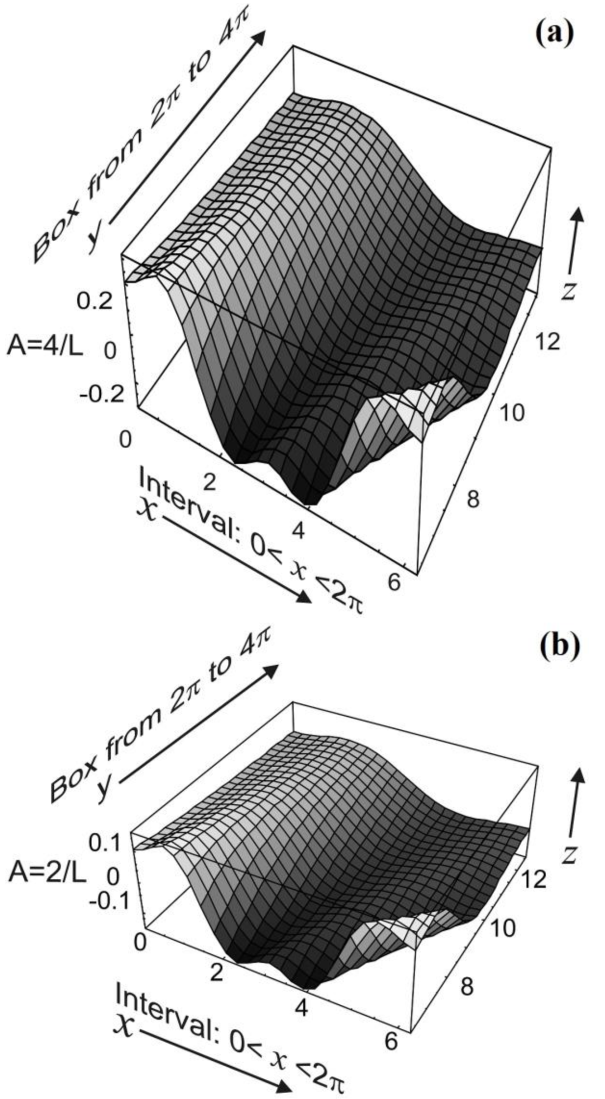

Figure 4: The 3D-dynamics of the PDC process. *The energy level equation in the Hermitic left was numerical adapted to Parametric down-conversion division of one photon into two by selecting amplitude:* $A = n_2 / L$, *and n_1= 2 and n_2= 4. For a)* $F(x,L) = \mathbf{4/L}[1/2 \times \cos(-2\pi x/L) - 1/6 \times \cos(6\pi x/L)]$, *$0 < x < 2\pi$* $\quad 2\pi < L < 4\pi$. *For b)* $F(x,L) = \mathbf{2/L}[1/2 \times \cos(-2\pi x/L) - 1/6 \times \times \cos(6\pi x/L)]$. *The equivalent energy correspondence: $E_2 < E_1$. Energy level 1 it's represented by the shorter wavelength (n=2) and energy level 2 a longer wavelength (n=4).*

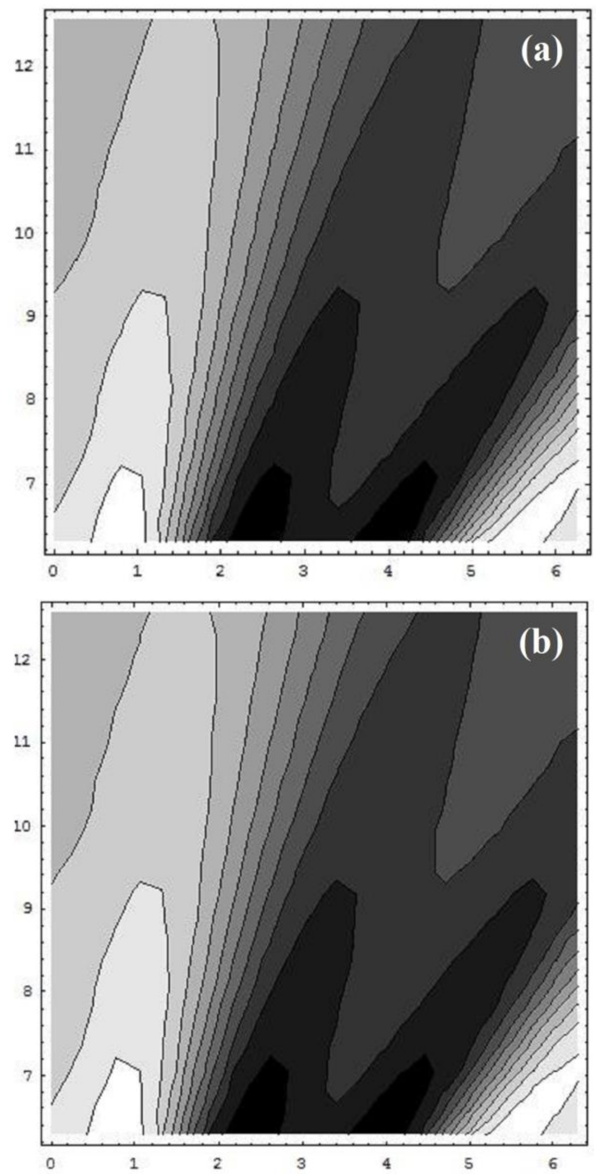

Figure 5: Contour-plot for the 3D-dynamics of the PDC *process (figures 4 a] and b]). A topographic representation, likes looking from above.*

Discussion

Several mathematical treatments are hereby tested, to further characterize the relationship of energy-space-time between its interactive levels. The quantum level of primordial energy in a multi-step dissipation into CMB-photon was analyzed. It shows an integrate correspondence by structuring dissipative potential of frequency density. The correspondence between quantum-microscopic and macroscopic scalar-levels was idealized by assuming that a quantum of space-time could be represented as an adiabatic Schrödinger's box.

Conclusions

The figures 3 to 5 illustrate the proposed integration of energy-space-time parameters, in an interaction, that by decreasing frequency induces a multi-step change of the quanta number, time and locus of localization. Its equivalent is the PDC model in which one photon generates two of twice wavelength. This time-space tension along the cosmos chronology, allows the continuous stretching of the wavelength containing space (λ-box), represented by the Schrödinger's box.

If applied to all the space, the integration of quanta, could be shown as λ-boxes extending to converge as an arrow of time, leading to the future extinction of the dissipative potential density of spectral energy or frequency density of CMB in relationship of its locus in the space-time.

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