A simulation shows the distinct roles of matter curving and CMB expanding space

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Abstract

The premise of an earlier universe, dominated by radiation, lead to a simulation based in that a decrease in energy of *primordial-quanta,* eventually yielding matter and a residual Cosmic Microwave Background (CMB) of 0.012% from total energy. Characterization of the latter, in terms of a continuum of energy-space-time quantum dimensioning dynamics, shows that a decrease in energy density of photons, with an increase in their relationship radius vs. time of localization equal to *c*. This relationship corresponds, with the increment of the cosmic space radius vs. universe time similarly conforming to *c*, the velocity of light. Parametric down-conversion (PDC), fits as energy conservation mechanism, which allows a continuous renewal of a dissipative potential, by splitting a photon into two of twice the *original wavelength*. The newly created photons emerge uniformly stretching-out space. Calculation shows that the number of emerging CMB-photons per second per Mpc when linearly aligned corresponds to the value of the Hubble constant (H_0). Recession velocity $\vec{v} = H_0 \times \vec{r}$ as a function of the radius and time of the universe when $r = r_U$ in Mpc units equals velocity of light over H_0: $r_U = c / H_0$. Accordingly, the model could by denominated: ***E**nergy **S**pace-**TI**me **R**elativistic **E**xpansion* (E.S.TI.R.E., Spanish) or S.T.R.E.T.CH.: Space-Time Relativistic Expansion Cosmological Hypothesis. PDC photon-splitting by magnification of the space-time locus of photons dominates over the scarce response of CMB to gravitational attraction. Moreover, since their mass in terms of the cosmos total mass is rather insignificant, the curvature of the cosmos could be regarded as CMB-independent near-independent mechanism. The plotting of the PDC continuum of CMB quanta elongation, when scaled vs. the expansionary universe volume, shows a straight line curve. This one represents a continuous thermodynamic-expansionary relationship, in which one photon entering into a PDC cycle, distributes its original energy over a space-time locus incremented 16 times. By analogy, this may be considered a thermodynamic prediction equivalent to *"flat"*, because any other numerical relationship, curves out of the observed relationship between increments in number of photons and volume of the universe. The particle and radiation roles, may be complementary because CMB would dimension vacuum and galactic recession, whereas the non-continuum quantum structure of matter, would be the dominant effect over the geometric configuration of the universe curvature. Hence, matter by its gravitational attraction, could overcome galactic recession by a uniform CMB-vacuum expansion, and would be driving galaxies into forming cumulus. However, expansion incrementing distances, would decrease the intensity of gravitational attraction over CMB, and could predict the observable accelerations of the rate of expansion. Inflation, in a self-contained universe, may correspond to the time required for quantification of an unknown energy-space-time, progressing from a single Planck-particle, to reach a Planck quanta-constituted critical mass, and the emergence of the associated fundamental constants: $m_{Pl} = [(\hbar \times c)/G]^{1/2}$. The universe has maintained an energy potential, allowing expansion and life. Therefore, it is still far away from equilibrium. However, if the cosmos is self-contained could not be open. This apparent contradiction was solved by considering that photon elongation could play an operator role, continuously restructuring the cosmic thermodynamic dissipative potential. A steady state away from equilibrium, which resembles an open-system, could be obtained by recycling through the PDC temporal bottleneck, the generated lower energy photon. These, would reenter into the PDC splitting chain, again and again like quanta of less and less energetic content.

Introduction

Parameters for the chronology of space changes, during the inflationary Era of the hot Big-Bang, had been develop based in the positive vacuum mechanism of Guth *et al* [1, 2, 3, 4] and Linde [5, 6, 7, 8, 9]. The hot Big-Bang hypothesis develops, a particle-based thermodynamic chronology, with successful predictions like nucleosynthesis.

The simulation goal was to further characterize the Big-Bang, by seeking to uncover space-time energy relationships, between the thermodynamic structures of radiation quanta from Planck to present CMB [10].

Evolution of radiation quanta, have been inferred as the dynamics constitutive expansive bricks of the space-time, and of its intrinsic thermodynamic restructuring driving inflation and expansion [11].

The simulation parameters were developed, in order to fit or to test theoretical frameworks, which could be subject to verification by observational data. Accordingly, multi-universe propositions were avoided. Instead, it was assumed that, a Big-Bang chronology could be developed by assuming a non-identifiable transition, from a non-quantum primordial structure, leading into the appearance of a cosmic quantum structure of energy and locus of space-time [12, 13].

Energy, and matter inflow and outflow, through thermodynamic systems, allow maintaining energy potentials, without reaching equilibrium. Primordial energy, could be characterized as a matter precursor; therefore, Planck particles influx during inflation, would be able to maintain the increasingly quantized-universe as open.

However, after becoming totally quantized, and reaching critical total energy, its density should suddenly decrease, allowing entropy to increase and inflation to end.

PDC and parametric up-conversion (PUC), had been experimentally observed as spontaneous energy conservation processes, the former could increase cosmic entropy by decreasing energy density.

Results

The transition from a non-quantified state, preceding the Big-Bang, initiates physically describable relationships, between energy and space-time. This results, in the appearance of time-associated phenomena, resulted in a chronology that delimits the relationships between fundamental constants, by their equivalence to the Planck mass: $m_{Pl} = [(\hbar \times c)/G]^{1/2} = 2.17645\times10^{-5}$g, G = gravitational constant = 1.0692068×10^{-13} cm^5 / MeV.s^4. Planck length, would be the one for an arc circumference of $2\pi r = \lambda$ and $r = \lambda / 2\pi$, therefore, $r = 1.61624\times10^{-33}$ cm. Time of localization for a Planck particle: $t_{p\text{-loc}} = r / \boldsymbol{c}$ $=5.39121\times10^{-44}$ s, same value is obtained: $t_{p\text{-loc}} = [hG / 2\pi c^5]^{1/2}$.

$$G = \frac{t_{Pl}^2 \times c^5}{\hbar} = \frac{\hbar \times c}{m_{Pl}^2} \quad t_{Pl}^2 \times m_{Pl}^2 = \frac{\hbar^2}{c^4}$$

The dynamics of the wave function of primordial energy, was characterized thermodynamically, as a decreasing frequency associated to an increase of its intrinsic space-time locus $-\Delta\nu = -(\Delta E / h)$. Since $1/\nu = t_{\lambda\text{-loc}}$, time of wave localization. The latter, could be illustrated by the fact that if a diaphragm is set to remain open, only for the $t_{\lambda\text{-loc}}$ of a violet photon (400 nm $\approx 1.33\times10^{-15}$ s) allows its transit. Hence, conceptually λ define not only length but also the time required to become localized outside the diaphragm. The time required for the smaller violet photon, would be to short for the appearance of the larger red photon (700 nm $\approx 2.33\times10^{-15}$ s).

Relativistic dimensional relationships of the duality wave-photon

The following equations emphasize that for the same energy, the duality wave-photon allows space-time dimensional differences.

Eq. 1: $E = h\times\nu \wedge t_{\lambda\text{-loc}} = 1/\nu \Rightarrow E\times t_{\lambda\text{-loc}} = h$, $t_{\lambda\text{-loc}}$ time of wave localization, ν is frequency and h = 4.1356674335 × 10^{-21} MeV.s. For the photon: $E \times t_{\gamma} = \hbar$, $t_{\gamma\text{-loc}} = 1/2\pi\nu = 1/\omega$, ω= angular frequency and $\hbar = h/2\pi = 6.5821191503 \times 10^{-22}$ MeV.s.

$$\sqrt{\frac{\hbar c}{G}} = \sqrt{\frac{6.58\times10^{-22}\, MeV.s \times 2.99\times10^{10}\,\frac{cm}{s}}{1.069\times10^{-13}\,\frac{cm^{5}}{MeV.s^{4}}}} = 13.585\,\frac{MeV}{\frac{cm^{2}}{s^{2}}}$$

Eq. 2. a) $\lambda / t_{\lambda\text{-loc}} = c$ (velocity of light) = $2.99792458 \times 10^{10}$ cm/s.

Eq. 2. b) According to Compton scattering measurements the relationship $\lambda_{CMB}/2\pi = r\gamma$, relationship between photon radius and time of localization: $r_{\gamma} / t_{\gamma\text{-loc}} = c$

Hence, c is not only the value for velocity of light propagation in vacuum, but also restricts at a quanta level the inter-dependence between space dimensions as a radius vs time.

Eq. 2. c): $\Delta r_{U} / \Delta t_{ru\text{-loc}} = c$. The relationship shows that the constant c, also determines the cosmic relation that applies to vacuum, as if corresponding to the summa of its constitutive quanta.

In eq. 2. a) y 2. b), terms are equal to c, and, therefore, equal within them.

$\lambda / t_{\lambda\text{-loc}} = r / t_{\gamma\text{-loc}}$. Time of localization = $t_{\lambda\text{-loc}} /2\pi = t_{\gamma\text{-loc}}$.

Eq. 3: Of the relation $[\hbar\, c/G]^{1/2} = m_{P}$ = Planck mass = 2.17645×10^{-5}g. Mass can be replaced in the Einstein's equation $m=E/c^{2}$ (15) (16), if E_{P} is assigned to $E \therefore [\hbar\, c/G]^{1/2} = E/c^{2}$.

It can be replaced $c^{2} = c \times c$ substituting each c by their equivalents 2. b) ó 2. c) and the other by 2. d).

$$\textbf{Eq. 4:}\; m_{Pl} = \frac{E_P}{\frac{r_\gamma}{t_{\gamma-loc}} \times \frac{r_U}{t_U}}$$

Hence, the formula $h / 2\pi = E \times t_{\gamma\text{-loc}}$, shows that, to maintain invariant h, the Planck constant, a decrease in photon energy, have to be compensated by an increase in the time of photon localization, that can be calculated ∴ $c / r\gamma = 1/ t_{\gamma\text{-loc}} = \nu \therefore c = \nu \times r\gamma$. Hence, to maintain invariant c a decrease in the frequency or photon energy $E\gamma$, has to be compensated with an increase in the Compton-$r\gamma$.

Inflation

The constants, Planck and velocity of light, delimits a quantum chronology of photons, coupling a decrease in energy density to an expansionary increase of their space-time locus. The surging of the space-time, delimited by the fundamental constants, dimensions the initial state of the cosmos as that required for a single Planck quantum. The cosmos would grow as a function of the primordial transition of the inflationary era, adding Planck particles until reaching critical or total energy.

The first phase of inflation could, therefore, be characterized as a tetra dimensional growing cosmos, which in spite of its very rapid increment in volume by increasing the contained number of Planck quanta, remains at constant energy density, without increasing entropy.

Inflation could, therefore, operate temporarily like an open system [14]. An isolated system, like a self-contained universe, can exist as an open system, for as long a bottleneck does not allow its energy potential to become dissipated by reaching equilibrium. The Planck limits, prevents instantaneous events, allowing c to configure a bottleneck by linking the stretching of a quantum space with its time of localization.

The value of this link is c, which remains invariable along inflationary and expansionary Eras [15, 16].

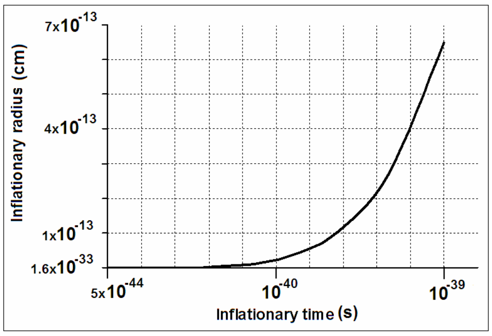

Figure 1: Inflationary influx of Planck Quanta*; an invariant entropy phase, would remain constant even when the quantum structured*

universe dramatically expands, provided continuous increment in the number of Planck photons. The plotted values result from assuming that the influx of one Planck quantum expands its locus space volume for another 15 quanta, which in turn undergo PDC-splitting. The process end into the total energy contained in the universe quantized, with its radiation spectrum resembling that of black body emission.

Figure 1, the inflationary phase [1, 2, 3] could be described as occurring at a larger velocity than that of light, because the initial space-time for a single Planck particle would be growing exponentially as a function of the incoming Planck plus PDC quanta multiplication. A uniform popping-out of photons allows an all directional growing of the quanta structure of the space-time. Hence, velocity as the time required for incrementing the universe radius could be larger than *c*, even when any reached radius divided by its localization time equals c, the constant.

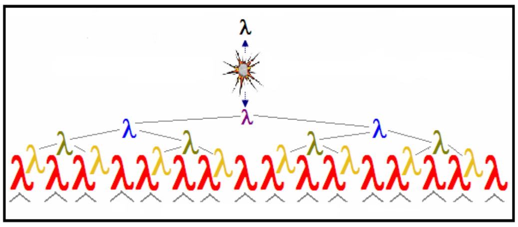

***Figure 2: Scheme for PDC-splitting photons** that increase their number and dimensions, at multiple sites uniformly incrementing space.*

Figure 2, in the bases of parametric down-conversion [17]: 1 $\gamma \rightarrow 2\gamma$ each 8 times greater: initial $V_\gamma \times 2\gamma$ = total 16× initial V_γ per event of the PDC sequence.

The number of photons progression illustrates that effect of splitting a single photon by PDC yields two photons, each one increasing by 8 its volume and expanding quantum space by 16, as shown below in two cycle's space expands by a factor of 256: $\gamma_{Pl},(E_{Pl})V\gamma_{Pl}=1.76\times10^{-98}cm^3 \rightarrow$ first PDC cycle$\rightarrow 2\gamma(E/2)2V\gamma_2\times8=2.82\times10^{-97}cm^3$ $\rightarrow$ second PDC cycle$\rightarrow$ $4\gamma(E_{Pl}/4)$ $=4V\gamma\times8^2=$ $4.51\times10^{-96}cm^3$.

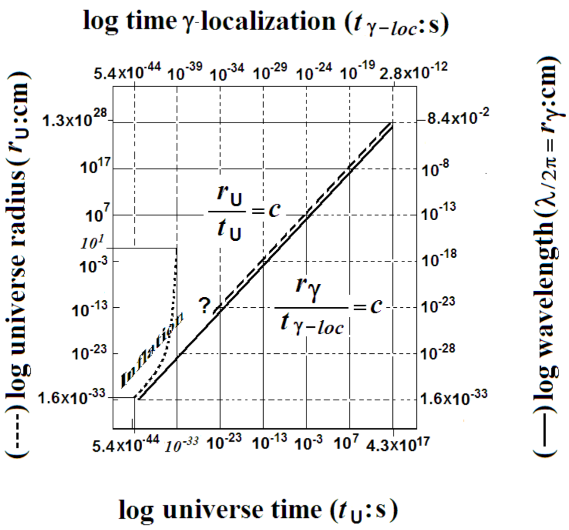

***Figure 3: Radius of the universe (r_U: cm) during inflation-expansion vs. universe time (t_U: s).** Intersections showing that the ratio between present universe radius and present universe time 1.3×10^{28} cm / 4.351×10^{17}s = **c**, the velocity of light. Resulting curve is shown correlated with the corresponding wavelength increment (according to Compton reactive radius: $\lambda/2\pi$= $\mathbf{r}_\gamma$: cm) universe time ($\mathbf{t}_U$: s) and vs time γ-localization ($\mathbf{t}_{\gamma\text{-loc}}$) curve intersections showing: $\mathbf{r}_\gamma/\mathbf{t}_\gamma$= **c**.*

Figure 3 shows a correlation between the elongation curve for CMB calculated as a Compton radius (λ_c) and the photon decrease in energy (E_γ) [18]. The present volume of the universe (V_U) corresponds to the cosmic number of photons ($n\gamma$) multiplied by the volume of λ-localization ($V_{\lambda c\text{-}loc}$). The latter, calculated according to the Compton wavelength (λ_c) measured by experimental collision interaction between an electron and a photon: $V_{\lambda c\text{-}loc} = 4/3\times\pi\times\lambda_c^3$.

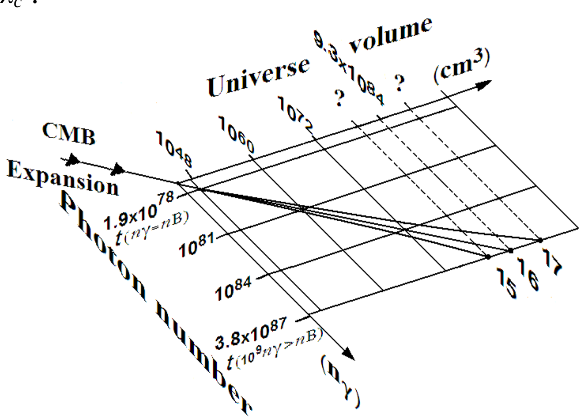

Figure 4: CMB elongation dependent-expansionary vacuum. *The figure illustrates that the simulation fits observation values from the Era of equal number of photons and baryons to present CMB. It shows a continuum of radiation quanta of decreasing energy, with increasing photon number and volume.*

Figure 4, the values ($n\gamma$) were scaled to show its time-dependent increase from Era of equal number of photons and baryons $t_{(n\gamma=n\mathrm{B})}$, $n\gamma = n\mathrm{B} = 1.9\times10^{78}$ at 2.391×10^{5}s to $t(10^{9}n\gamma>n\mathrm{B})$, $n\gamma_{\mathrm{pres.}} = 3.8\times10^{87}$ at the present Era. The initial photon volume at $t_{(n\gamma=n\mathrm{B})}$ $\mathrm{V}_{\gamma(n\gamma=n\mathrm{B})} = 9.5\times10^{-31}$ cm^3 $\times$ $n\gamma$ equals the volume of the universe $\mathrm{V}_{\mathrm{U}(n\gamma=n\mathrm{B})} = 1.5\times10^{48}$ cm^3. The PdC-dependent volume increase measured by the ratio of $\mathrm{V}_{\mathrm{U\text{-}pres.}}/\mathrm{V}_{\mathrm{U}(n\gamma=n\mathrm{B})} = 6.2\times10^{36}$ requires a sequence of 31 PDC-cycle γ-duplicating events. This sequence generates a curve of value 16 responding to a thermodynamic tendency relating a PdC-γ splitting 16 increments of γ volume with a 16 increments in the volume of universe (flat?). The upper curve of value 17 predicts a larger universe volume (1.3×10^{89} cm^3) and the lower predicts a smaller universe (2.8×10^{81}cm^3).

Accordingly a description of vacuum as identical to empty space is far from accurate and instead could be inferred, that CMB-photons constitute a quantum structure denominated vacuum [11].

PDC divides a photon into two of twice the wavelength conserving energy and momentum. Thus, by being spontaneous, neither raises a thermodynamic barrier for direction reversal, nor increases by much entropy at the photon level. However, an increase in entropy occurs at the system level as a result of that energy density decreases, as a function of cosmic volume increment. The Down-Conversion constitute the favored vector direction, because the splitting of one into two photons is a kinetic more favored process, than the up-Conversion which requires a second order reaction or, in other words, a collision between two photons to merge into an upper level of energy.

However, it could be predicted, that along the parameters of space and time, fluctuations between Up and Down Conversions, would settle into a relationship of rates that could show in the Casimir effect appearance and disappearance of photons with higher energy than CMB. These shorter λ photons are generated from CMB-containing (constituted?) vacuum, and therefore, could be inconsistently attributed as coming out of nothingness an assumption reserved to virtual energy, in accordance to Heisenberg's uncertainty principle.

Relativistic dimensional relationships of Hubble's constant

PDC continuously generates new photons; the summa of their radius was calculated to reach a length of about to 72 km/s per Mpc. Therefore, PDC present rate of CMB-splitting within one Mpc was found equivalent to that of the Hubble's constant (H_0). This veolocity because the photons emerge uniformly into space, would add as the summa of the number of parsecs that separates two galaxies. The radius of the universe divided by the present CMB-diameter per photon equals the number of photons linearly aligned to cover the distance of the universe radius:

$$\frac{1.3\times10^{28}\,cm}{1.68\times10^{-1}\,cm} = 7.74\times10^{28}\,photons\,.$$

This number divided by the universe time in s corresponds to the emerging number of photons incrementing the radius of the universe during every second:

$$\frac{7.74\times10^{28}\gamma_{CMB}}{4.34\times10^{17}s} = 1.78\times10^{11}\gamma_{CMB}/s$$

Multiplied by of diameter of photon and divided by the universe radius express in Mpc, 4216.446, result in the stretching out of every Mpc by the newly add photons which represent recession velocity for each Mpc or H_0 value:

$$\frac{1.78\times10^{11}\gamma_{CMB}/s\times1.68\times10^{-1}cm}{4216.446Mpc} \approx 72Km/s/Mpc$$

Recession velocity corresponds to the simultaneous and uniform incorporation of photons, adding H_0 velocities accordingly to the number of Mpc, because this photons influx, stretch-out over every Mpc segment of the total intergalactic distance.

Hence, recession velocity is related to H_0 and proportional to the distance *r* and when calculated as the distance between us and the Big-Bang origin (singularity or a Planck locus?) accordingly to equation: $\vec{v} = H_0 \times \vec{r}$

$$\frac{72\text{km/s}}{1\text{Mpc}} \times 4216.4\text{Mpc} = 3\times10^5\,\text{km/s} \approx c$$

Accordingly, the radius of the earth location to the origin of the universe, allows causal contact, because the velocity of the summa of recession within each parsec, does not exceed *c*. The *c* relationship precedes and persists along the expanding radius for any encompassed relativistic time. Recession has been shown to be accelerating. The question: it is a mere casualty that, at the present time we have reached the maximum value of the Hubble's constant, allowing a causal integration for the present observable universe?

Hence, calculation shows the equivalence between CMB vacuum expansion and galactic recession indicating that both may result from the same process. PDC predicts that even is the photons travel at the velocity of *c*, their space-time locus expansion is the mechanism expanding CMB intergalactic vacuum. CMB lengthening or elongation involves an increase in their time of localization. Accordingly, recession distance per Mpc may increase and the number of Mpc lengthening the circumference of the universe will also increase. However, the time increment required for subsequent PDC cycles would compensate the increasing H_0 tacking for expansion a longer time and allowing a velocity of recession that remains equal to *c*.

Conclusions

A simulation based in wavelength elongation with parametric down-conversion incrementing the photon number [10] was used to plot the dimensioning evolution of the Universe as a function of the decrease in frequency of primordial energy. Thus, accounting for the equal number between particle and radiation Era to the present, a photon number increased over that of particles of about 2^{31} (figure 4).

Inter-conversion between photons of different λ by the simultaneous occurrence of PUC and PDC events [17] is allowed because both processes are spontaneous, even when the dynamic of this equilibrium favors cosmic expansion and could be detected as the chaotic noise characteristic of vacuum fluctuation.

CMB, if a relic, only conserves 0.004 % of the initial critical energy. It was therefore assumed and used as a correction that at the end of the Inflationary period [11] the energy of most primordial photons had been converted into ordinary and dark matter. Connes [19] postulates the geometrical coexistence between a non-continuum and a continuum [20]. The simulation adapted this concept to that of coexistent thermodynamic structures, in which the non-continuum is constituted by ordinary and dark matter and the continuum, by that of the evolution of initial radiation and dark energy. At the enunciation of the relativity theory [15, 16], CMB had not yet been detected, and therefore could not be predicted a quanta constituted dynamic vacuum, and a quanta dimensioning of the space-time, configuring galactic recession.

Einstein's description unifying space, time and energy as a geometrical continuum may be from analysis of CMB vacuum data, reinterpreted to imply: the continuum evolving of a cosmic thermodynamic structure of quanta-integrated space-time.

An always valid and illuminating guiding hypothesis, which I read from the Penrose's book [21] (translating from Spanish to English): "what fundamentally is needed, is a subtle change of perspective… something that all of us had by pass". For this advice I am grateful.

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