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Quantum-Relativistic Properties of the Space-Time Bubbles and Their Evolution in a Multi-Bubble Universe

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Abstract

The quantum-relativistic properties of space-time bubbles introduced in the recently proposed multi-Bubbles Universe model have been studied and deepened in the framework of the electromagnetic Bridge theory. In this context, it is shown how the space-time fabric of the emerging universe and the primordial matter contained in it, can be considered the final result of the decay of a pre-universe formed by a BEC of neutral Planck bosons hidden under the space-time horizon, having the characteristics of balancing gravitons associated with the potential energy of the vacuum defined as the field of nothingness. The estimated mass of the Planck boson is compatible with the smallest of the Kaluza-Klein graviton with an energy mass of 2.68 TeV, this value allows to estimate the limit of the Planck energy scale characterized by a lepton particle with a rest mass of 1.27 TeV. It is also shown as an ancient multi-bubble universe obtained by the decay of a pre-universe redshifted nowadays at 2.725 K, provides a Planck blackbody spectrum perfectly in agreement with the cosmic microwave background radiation of our universe measured by the COBE satellite.

Keywords

Bridge Theory, Multi-Bubbles Universe, Balancing Graviton, Spacetime

1. Introduction

The universe can be considered as an isolated system for which the "outside" makes no sense because all that exists are "inside". All components of the universe that exist or are thought to exist such as spacetime, matter, antimatter, dark matter, energy and dark energy, must therefore have a common origin and maintain the same initial values of energy, momentum and angular momentum that the universe had before it began to exist, *i.e.*, zero.

The first to propose the idea of quantum fluctuations in the space-time metrics was John A. Wheeler, in his model the fluctuations of the order of Planck length form a tiny foam, micro-bubbles of spacetime. The same idea was subsequently developed and addressed with different theoretical models, all in accordance with the basic idea, *i.e.*, spacetime is formed by quantum bubbles [1]. The successive S. Hawking's idea that the evaporation of macroscopic black holes produces virtual micro-black holes [2] that represent a metastable false vacuum, suggests the existence of a possible engine for the recycling of matter and the continuous formation of new bubbles from nothingness [3]. This last idea is very close to that presented in the multi-Bubble Universe model (MBU) in Ref. [4] which however is based on an electromagnetic approach to quantum-relativistic theory that gave rise to the electromagnetic Bridge theory (BT) [5] [6].

The BT originates from the conjecture [7] on the role of the transverse component of the Poynting vector of the dipole formed by a pair of charged particles in electromagnetic interaction that, regardless of their rest mass values, locates inside the first wavefront of the source a quantity of energy and a moment describable in the form of a quantum of energy, a virtual photon with zero spin and with energy and momentum that correspond to those of the two interacting particles. The conjecture [7] has been demonstrated in subsequent works [8] and [9] by means of a high-precision theoretical estimate of the fine structure constant that in BT has the role of a fundamental constant that characterizes the electromagnetic coupling between field and charge, consequently the value of Planck's constant loses its role as a fundamental constant of the universe.

The emerging idea is that whenever there is a direct interaction between a pair of charges, the coupling is always electromagnetic and occurs by forming a Dipole Electromagnetic Source (DEMS) that locates the total energy and momentum of the interaction in the form of a quantum, *i.e.*, a photon. Recently in Ref. [10] the same concept has been successfully applied to the formation by spontaneous electron capture by a proton of a hydrogen atom.

As proved in Ref. [5] and [6], quantum theory and special relativity have a common origin starting from electromagnetic phenomena, from which it has also been shown that Heisenberg's uncertainty principle can be derived, which involves the products of the conjugate pairs of variables energy, time and space, momentum, unequivocally linking their product to the value of the Planck action generated by the formation of a DEMS. This same formal and conceptual link suggests that space-time can only exist if a DEMS exists.

In the MBU model [4] the universe is described as formed by foam of DEMS resulting from the decay of bosons having also the role of balancing gravitons (BG).

In this scenario, the vacuum, understood as a space-time fabric, emerges as an effect of the formation and expansion of the electromagnetic field associated with a wave of a DEMS produced by the spontaneous decay of the BG in a pair of particles. In this case the DEMS are a gurgle of spacetime that give rise to matter. In Ref. [4], however, some aspects related to the formation of space-time bubbles have not been treated or sufficiently deepened. In this work we will analyze carefully the model of creation of a bubble of spacetime with a primordial leptonic matter, within which everything seems to originate as a result of spontaneous quantum fluctuations of the action value. To do this it is necessary to use the BT from which the MBU model derives.

2. The Electromagnetic Origin of Quantization

Considering a pair of particles in interaction, Poynting's theorem gives us the possibility to write that the mechanical work per unit volume done on the charges by the Coulombian force plus the rate of change of energy density is equal to the flow of energy entering the unit of volume:

$$\boldsymbol{J}\cdot\boldsymbol{E}+\dot{u}=-\nabla\cdot\boldsymbol{S} \tag{1}$$

Following the conjecture in Ref. [7], considering a portion of spacetime, if no particle comes in or out the spherical surface $\Sigma(t)$ placed around a DEMS and if every point of the surface moves from the source with a uniform radial motion, by using the Poynting's theorem in the form (1) and the divergence theorem, it is possible to write along any radial spatial direction (θ,φ) a conservation law for the specific directional contribution to the total energy

$$\delta\varepsilon(t)_{tot}=\int_{V_{\delta\Sigma}}u(t)\,\mathrm{d}x^3+\varepsilon_{mec} \tag{2}$$

inside the volume $V_{\delta\Sigma}$ of the ideal spherical crown delimited by two concentric spherical surfaces associated to an initial and a final time. Deriving it with respect to time, the Equation (2) describes the variation of energy within the generic spherical surface $\Sigma(t)$:

$$\delta\dot{\varepsilon}(t)_{tot}=\delta\dot{\varepsilon}(t)_{mec}+\delta\dot{\varepsilon}(t)_{field}=-\oint_{\Sigma(t)}S\mathrm{d}a\,. \tag{3}$$

If the mechanical energy which supplies the electromagnetic source during the interaction is provided from outside, so that $\delta\dot{\varepsilon}_{mec}=0$, the total energy variation inside the spherical crown of volume $V_{\delta\Sigma}$ will depend only on the electromagnetic field, thus $\delta\dot{\varepsilon}(t)_{tot}=\delta\dot{\varepsilon}(t)_{field}$. By integrating Equation (3) over the arbitrary time interval $[0,\tau]$, we obtain (see Equation (5)):

$$\delta\varepsilon(\tau)_{tot}=-\int_0^\tau\left(\oint_{\Sigma(t)}S\mathrm{d}a\right)\mathrm{d}t=\delta\varepsilon(0)_{tot}-\frac{1}{c}\int_{V_{\delta\Sigma}}S\mathrm{d}^3x \tag{4}$$

where the zero-energy level due to the electromagnetic energy density

$$\delta\varepsilon(0)_{tot}=\int_{V_{\delta\Sigma}}\frac{E^2+B^2}{8\pi}\mathrm{d}^3x+\varepsilon_{mec} \tag{5}$$

is the local energy at the initial time in which as a result of integration appears an arbitrary constant term that we assume to be due to the external mechanical origin.

Hence, by Equation (5), the Equation (4) rewritten in the form (2) at the final time of the interval $[0,\tau]$ becomes

$$\delta\varepsilon(\tau)_{tot} = \int_{V_{\delta\Sigma}} u(\tau)\,\mathrm{d}^3x + \varepsilon_{mec} \tag{6}$$

with

$$u(\tau) = \frac{1}{8\pi}\left(E^2 + B^2 - \frac{8\pi}{c}S\right) \tag{7}$$

local energy density at time τ in the volume $V_{\delta\Sigma}$.

If the electromagnetic source observed from a point P were ideal point, we should have the Poynting vector all radial:

$$S \equiv S_r = \frac{c}{4\pi}EB \tag{8}$$

with $E = B$ and consequently as presented in [7] the electromagnetic energy density (7) would be zero because all the energy produced by the source would be instantaneously emitted. A dipole, on the other hand, cannot be considered a point-like source, especially in the region of the electromagnetic field inside the first wavefront, for which the Poynting vector is not completely radial everywhere that is:

$$\boldsymbol{S} \equiv \boldsymbol{S}_r + \boldsymbol{S}_t = \frac{c}{4\pi}(\boldsymbol{E}_t + \boldsymbol{E}_r)\times\boldsymbol{B} \tag{9}$$

Therefore, considering the only radial component of the Poynting vector, the residual local energy density (7) will be greater or equal than zero localizing inside the considered volume a contribute to the total energy greater than the mechanical one

$$\delta\varepsilon(\tau)_{tot} = \frac{1}{8\pi}\int_{V_{\delta\Sigma}}\left(E^2 + B^2 - 2|\boldsymbol{E}_t\times\boldsymbol{B}|\right)\mathrm{d}^3x + \varepsilon_{mec} \geq \varepsilon_{mec} \tag{10}$$

This phenomenon as proved in Ref. [7] [8] [9] and [5] is at the origin of energy and momentum quantization. In fact, the excess of energy produces a quantum in agreement with energy and momentum of a photon.

3. The Extended Uncertainty Principle

Consider the amount of null local field:

$$a = \frac{E^2 + B^2 - 2|\boldsymbol{E}\times\boldsymbol{B}|}{8\pi} = \frac{E^2 + B^2 - 2|\boldsymbol{E}_t\times\boldsymbol{B} + \boldsymbol{E}_r\times\boldsymbol{B}|}{8\pi} = 0 \tag{11}$$

Calculated on the non-spherical wave surface of the dipole. From Equations (7)-(9) the quantity *a* satisfies the inequality

$$a \geq u(\tau) - \frac{|\boldsymbol{E}_r\times\boldsymbol{B}|}{4\pi}, \tag{12}$$

i.e.

$$u(\tau) \leq a + \frac{|\boldsymbol{E}_r\times\boldsymbol{B}|}{4\pi} \leq a + \frac{|\boldsymbol{E}\times\boldsymbol{B}|}{4\pi}. \tag{13}$$

Therefore, by integrating Equation (13) over the volume of the spherical crown $V_{\delta\Sigma}$ and dividing by speed of light, since $a=0$ the Equation (13) becomes

$$\frac{1}{c}\int_{V_{\delta\Sigma}} u(\tau)\mathrm{d}^3x \le \frac{1}{c^2}\int_{V_{\delta\Sigma}} S_t\mathrm{d}^3x \le \frac{1}{c^2}\int_{V_{\delta\Sigma}} S\mathrm{d}^3x \tag{14}$$

After a further integrating of the Equation (14) over all the angles of emission, at a variable distance from the virtual center of the source r less than or equal to the wavelength λ, in accordance with the estimate of the theoretical value of Planck's action constant obtained in different conditions in Ref. [5] [9] and [10] and with the definition of momentum

$$P_{spin} = \int_0^{2\pi}\mathrm{d}\phi\int_0^{\pi}\frac{1}{c^2}\int_{V_{\delta\Sigma}} S_t\mathrm{d}^3x\mathrm{d}\theta = \hbar k \tag{15}$$

Equations (14) and (15) yield

$$\frac{E_{res}}{c} \le \hbar k \le \frac{E_{field}}{c} \tag{16}$$

Considering an elapsed time τ less or greater than the characteristic period λ/c of the source, the Equation (16) can be rewritten in terms of energy and time uncertainty

$$E_{int}\tau \le h \le E_{ext}\tau \tag{17}$$

or equivalently in terms of momentum and position uncertainty

$$P_{int}r \le h \le P_{ext}r \tag{18}$$

where an observer internal to the wavefront: $r \le \lambda$, measures a momentum and a localized energy that satisfy the relationships

$$\begin{aligned} E_{int}\tau &\le h \\ P_{int}r &\le h \end{aligned} \tag{19}$$

Instead, an observer outside the DEMS wavefront: $r \ge \lambda$, measures a momentum and an energy satisfying the relationships at right of the Equations (17) and (18)

$$\begin{aligned} E_{ext}\tau &\ge h \\ P_{ext}r &\ge h \end{aligned} \tag{20}$$

The inequalities (20) refer to an energy and a momentum measured by an observer external to a microscopic wave source. This result agrees with the Heisenberg's uncertainty principle and with quantum phenomenology. In general, for a macroscopic observer, *i.e.*, larger than DEMS, the spherical surface of the front of the first wave-emission becomes a spacetime limit that in the space of the phases is transformed into a compact quantum of action h with estimated value weakly variable according to the physical conditions of the interaction between particles as proved in Ref. [5] and more recently in Ref. [10].

Inequality (19) is instead alien to quantum phenomenology but is a natural condition in the development of BT and is very important for the present work. In fact, the case in which an observer is imbedded into the electromagnetic field of the DEMS within the wavefront of propagation of the electromagnetic field is normal in the applications of Maxwellian electromagnetism.

In the following two distinct cases related to these two principles of uncertainty will be considered, the first is the most frequent in experimental situations and is the case in which a pair of particles interacts in spacetime, the second is the case of a very particular pair of particles created spontaneously at zero-point energy (ZPE) by a fluctuation of the action value in the field of nothingness. In the latter case it will be shown that spacetime is associated with the generation of the electromagnetic field in the expansion of the emitted wavefront and the consequent variation of energy within the DEMS border.

4. Interaction of Pairs of Particles in Spacetime: A Superluminal Wave-Particle Propagation

Consider the interaction of a pair of charged particles associated respectively to the frames S_1 and S_2. As described in Ref. [8] and [5], two charged particles approaching each other along their trajectories in spacetime will reach a reciprocal distance equal to 3/2 of their minimum interaction distance along their dipole axis that defines the measure of the wavelength λ of the DEMS that will be produced. In Ref. [6] it was proposed that this interaction violates the cause-and-effect principle produced by the superluminal speed of the de Broglie wave associated to the particles. In fact, the source zone of a DEMS associated with the interaction of the pair of particles begins to exist at $3\lambda/2$ and it grows by locating at the end of the approach process an amount of energy and momentum equivalent to that of a photon with wavelength λ with energy and momentum equal to those of the interacting particles. Dynamically this process is equivalent to a reciprocal exchange of an energy and momentum with virtual photons.

During the creation of the source zone, the diameter of the ideal spherical surface that delimits the front of propagation of the electromagnetic field of the DEMS increases. The apparent effect with respect to each of the two interacting particles is to have an electromagnetic front expanding and rotating with a time-dependent angular phase φ due to the internal spin of the field associated with the transverse Poynting vector component.

Its expansion speed is proved in Ref. [5] and [8] to be defined by $u_{exp} = c/\varphi$ with $0 \le \varphi \le \pi$ *i.e.*, when at the beginning the phase is $\varphi = 0$ the source zone starts to expand it with an infinite velocity decreasing with the phase value up to $u_{fin} = c/\pi$. After an elapsed time *T*/2 the source zone ends to expand it, the DEMS is complete and starts to emit energy radially as an ideal electromagnetic source. At this time a quantum of electromagnetic energy $E = hc/\lambda$ has been produced within the source zone and localized inside the wavefront.

Considering the observer S_1 placed on the particle #1 in motion of approach with respect the particle #2 with a relative velocity *v*, at phase $\varphi = 0$ using the relativistic sum of the velocity as in Ref. [6], the observer S_2 placed on the particle #2 measures the relative speed of the electromagnetic field on the other side of the DEMS propagating towards the particle #1 with speed

$$u_{dBw} = \lim_{\varphi \to 0} \frac{\frac{c}{\varphi} + v}{1 + \frac{v}{\varphi c}} = \frac{c^2}{v} \tag{21}$$

This is the speed of the de Broglie wave (dBw) of particle #2, which propagates superluminally towards particle #1 and vice versa. The information of the mutual interaction between the two particles in a relative way is exchanged symmetrically so that each particle knows before the complete formation of the DEMS the energy and momentum that will be exchanged during the electromagnetic interaction. The result of the direct interaction mediated by the formation of a DEMS, as proved in Ref [6], is to exchange energy and momentum $(E = \gamma\varepsilon, Pc = \gamma\beta\varepsilon)$ in a quantized way via a virtual photon, where $\varepsilon = 2mc^2$ is the energy of the resting mass of the pair of particles in interaction.

5. Spacetime of the Bubble and Its Relativistic Invariance

Inequalities (19) refer to the uncertainties of energy and momentum for an observer embedded in the electromagnetic field of DEMS within the wavelength wavefront $\lambda = hc/\gamma\beta\varepsilon$. In the case considered, the electromagnetic field can be generated by the electromagnetic interaction of a pair of pre-existing particles or a pair of newly created particles in a spacetime. Within the wavefront, space and time are the dimensions correlated by Equation (19) respectively the momentum and energy localized by the electromagnetic field of a DEMS. These two quantities define the where and when of an observer as a function of the values of momentum and energy measured by his instruments without the need to have reference points in space-time. In this sense, space and time are quantities derived from the state and electromagnetic characteristics of a DEMS.

Following Ref. [5], is shown that the electromagnetic energy emitted radially by a DEMS is a continuous and variable quantity depending on the radial distance from the virtual center of the source and the angle of emission. Considering as a variable the radius of the DEMS the resulting luminosity profile is

$$Y(r,\theta) = \frac{q^2}{4\pi r^3}\left(\frac{2r}{\lambda} - 1\right)\Theta_r(\theta) \tag{22}$$

which is able to describe a well zone with negative luminosity before the source zone threshold $r_0 = \lambda/2$ and a source zone within the range within which the source reaches its maximum brightness value, at a distance $r_{\max} = 3\lambda/4$.

The two radii $(r_0, r_{\max})$ characterize two ideal spherical surfaces Σ_0 and $\Sigma_{\max}$ that delimit a spherical crown defined source zone (SZ) of the DEMS, where the superficial luminosity increases gradually up to achieve a maximum value. After reaching the maximum, the luminosity gradually decreases until it reaches the initial electromagnetic background showing a behavior converging to that expected for an ideal point-like electromagnetic source.

By setting $\kappa = kr$ and introducing the dimensionless brightness

$$y_{dip}(\kappa) = \frac{4\pi Y(r,\theta)}{q^2 \Theta_r(\theta) k^3} = \frac{1}{\kappa^3}\left(\frac{\kappa}{\pi} - 1\right) \tag{23}$$

Converging asymptotically to an ideal point-like source with brightness

$$y_{id} \approx \frac{1}{\pi \kappa^2} \tag{24}$$

It is possible to compare the brightness profiles of the real dipole (23) with that of an equivalent ideal source (24). In Figure 1(a) is shown the well zone in $\kappa < \pi$ which by absorbing energy from the outside provides energy to the source zone bounded by the range $\pi \le \kappa \le 3\pi/2$. Figure 1(b) shows the comparison between the brightness profiles of the dipole and the ideal point source. It can be seen from the emission profile that for each value of z the energy produced in the source zone is greater than that instantly emitted. For $\kappa > 3\pi/2$ the luminosity decreases converging towards that of an ideal source. Outside the source zone, the radially emitted energy gradually reduces the amount of energy localized inside the source zone.

Using the Equation (19) for an observer in radial position $r = h/P_{int}$ inside the DEMS is possible to write

$$r_0 \le r \le \lambda \tag{25}$$

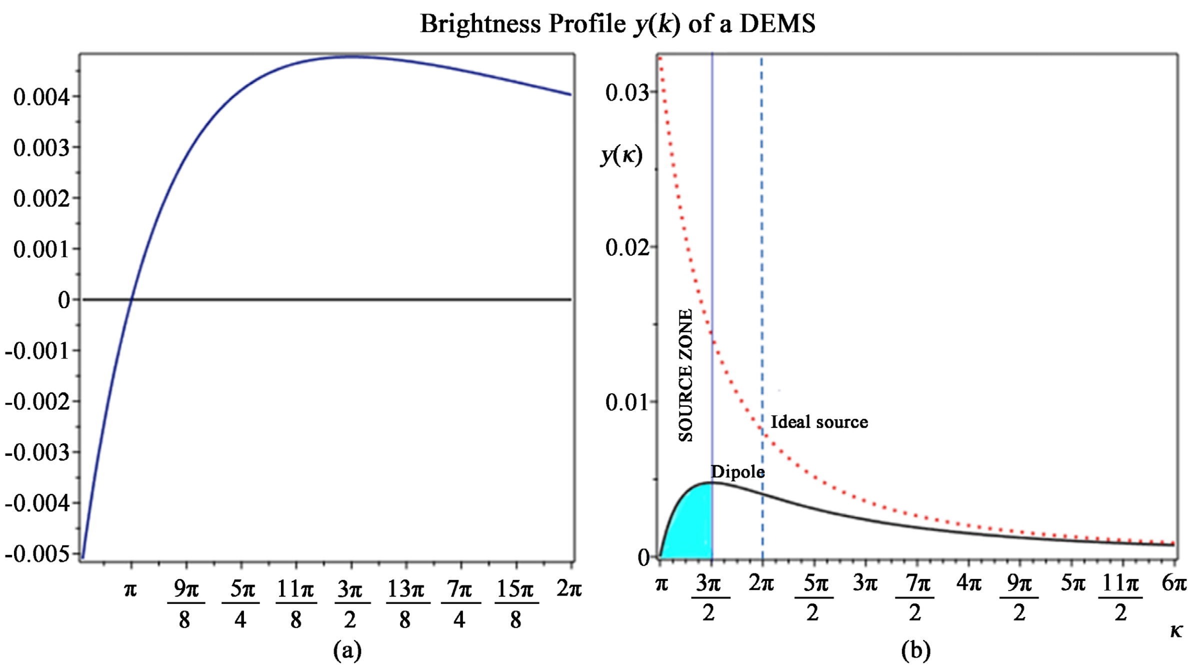

Figure 1. The emission profile of a dipole in (a) shows a well zone for $\kappa < \pi$ and a source zone in the range $\pi \le \kappa \le 3\pi/2$. The source reaches the energy balance on the wavefront $\kappa = 2\pi$ where the energy not yet emitted is equal to the energy emitted. In (b) the difference profile of emission between the dipole source and an ideal point-like source is highlighted. The source zone highlighted in light blue is where the electromagnetic energy provided by the well zone is localized. The brightness of the source increases from zero to a maximum in $\kappa = 3\pi/2$ after which the emission decreases gradually reducing the internal electromagnetic energy.

Let $t = r/c$ to be the apparent elapsed time from the instant in which the source zone of the DEMS starts to be produced and τ with

$$\tau \le \vartheta = \frac{h}{E_{int}} \le T \tag{26}$$

the correspondent real time of the dipole defined by the actual amount of internal energy E_{int} measured by the observer in his position *r*, limited above by the characteristic de Broglie's period *T* of the DEMS, the space-time position of the observer imbedded in the wave-field can be described by a set of two scalar coordinates: the radial position *r* expressed as a function of the three Cartesian sub-variables (x, y, z) defining the spherical surface around the ideal center of the DEMS $r^2 = x^2 + y^2 + z^2$ and the real time τ in Equation (26). Now using the definitions in Equations (25) and (26) it is possible to estimate the difference of the squares of the real and apparent distances travelled by the electromagnetic signal emitted by the source to achieve the position of the observer. This difference builds the space-time invariant of the DEMS by providing the invariant distance travelled by an electromagnetic signal during the proper time necessary to produce the source:

$$c^2\tau^2 - x^2 - y^2 - z^2 = -\frac{h^2c^2}{\beta_{dBw}^2 \gamma_{dBw}^2 E_{int}^2} \tag{27}$$

The right term of the Equation (27) is the square of the de Broglie wavelength associated with the DEMS produced by the interaction of the created pair and is a positive quantity because the wave signal emitted during the direct interaction propagates with the superluminal veocity (21), *i.e.*, with a de Broglie speed $\beta_{dBw} = 1/\beta > 1$ and with a relative particle antiparticle speed $\beta = v/c < 1$.

In fact, using the corresponding imaginary de Broglie's gamma factor $\gamma_{dBw} = i\beta\gamma$, the Equation (27) rewritten in terms of relative velocity of particles with β and γ becomes

$$c^2\tau^2 - x^2 - y^2 - z^2 = \frac{h^2c^2}{\gamma^2 E_{int}^2} \tag{28}$$

Considering the observer placed on one of the two particles originating the DEMS, after their formation each particle moves away from the ideal center of the DEMS along the axis of the dipole *d* and is associated with half of the dipole wave field, that is, both particles placed at the symmetrical ends of the dipole axis are associated with an electromagnetic mass energy and a momentum localized in the respective surroundings of the source zone of the DEMS bounded by the spherical crown of diameter in the range $\lambda < d < 3\lambda/2$. When the source zone is formed, the particles are at a minimum distance from each other equal to the wavelength of the source. Following the BT in Ref. [6], with respect to the center of mass of the source, the total electromagnetic energy within the source zone of the DEMS is equal to the resting mass energy of both particles *i.e.*, the internal energy converges to the total rest mass energy of the interacting particles: $E_{int} \to \varepsilon = 2mc^2$. The denominator of Equation (28) thus converges on the Broglie energy of DEMS

$$\gamma^2 E_{int}^2 \to E^2 = \gamma^2 \varepsilon^2 \tag{29}$$

Where the gamma factor depends by the relative velocity of approach or removal of the particles. Using the equation of the characteristic period of the DEMS $T = h/\gamma\varepsilon$, the Equation (28) becomes the invariant of the space-time bubble at four dimensions

$$c^2\tau^2 - x^2 - y^2 - z^2 = c^2 T^2 \tag{30}$$

With $\lambda = cT$ invariant wavelength with respect to any observer with $T = h/E$ proper time characterizing the de Broglie wave period of the wave-particle measured by a clock connected to one of the escaping particles. In other words, Equation (30) allows to classify as simultaneous all the time-like events placed on the de Broglie wave surface, therefore having identical length λ of the lines of the universe.

Using the Equation (30), it is possible to describe the real time τ elapsed from the beginning of the formation of the DEMS source zone to the moment at which the observer in the radial position r receives and observes the electromagnetic signal not experimentally measurable by the observer's clock

$$\tau = \sqrt{T^2 + \frac{x^2 + y^2 + z^2}{c^2}} \tag{31}$$

and the apparent time t, that is, what the observer considers the physical time measurable from the moment the formation of the source zone ends

$$t = \sqrt{\tau^2 - T^2} \tag{32}$$

Both definitions of time (31) and (32) are fixed by the initial position of the observer and by the proper time of the DEMS.

Considering the observer placed on one of the two moving particles, during the removal the wavelength that characterizes the direct interaction of the pair increases with the consequent decrease in the internal energy of the source. It is possible in this way to express the real time τ and the proper time T both as function of the localized energy inside the corresponding bubble. In fact, defining $E^* = \gamma E_{int} \le \gamma\varepsilon$ the energy of the electromagnetic bubble, during the removal phase (stretching of the wavelength of the DEMS) the bubble expands and the energy decreases, the real time results to be $\tau = h/E^* \ge T$, consequently the apparent time measured by the observer is defined in terms of the energy decrease within the spherical bubble on whose surface the observer is placed

$$t = h\sqrt{\frac{1}{E^{*2}} - \frac{1}{E^2}} \tag{33}$$

Equation (33) gives an apparent physical time $t = 0$ before the emission and removal of the two interacting particles and an apparent time $t > 0$ ever-increasing measured by the clock of the observer and estimated as a function of the energy decreasing inside the expanding bubble. The rewriting of the Equation (33) in the factorized form

$$t = h\sqrt{1-\beta^2}\sqrt{\frac{1}{E_{int}^2}-\frac{1}{\varepsilon^2}} \tag{34}$$

highlights how for identical pairs of particles emitted with different relative speeds, observers record a different physical elapsed apparent time because Equation (34) decreases with the relative speed of the emitted particles.

In general, considering an observer in interaction with several other observers, each with different relative velocity, the time of each space-time bubble associated with each interaction will be different, as it depends on the relative velocity of the individual pairs of observers in interaction, that is, there is not a single observer time with respect to the rest of the universe but a different observer time for each bubble of the universe. In a bubble time slows down to a halt for speed values close to the speed limit of light. From an energetic point of view, the lower the speed of the particles emitted, the slower the rhythm of time measured inside the bubble. In the ideal case of a source zone with emitted particles not moving, therefore associated with a space-time bubble that does not expand, the physical time of the observer remains zero.

Defining

$$t' = h\sqrt{\frac{1}{E_{int}^2}-\frac{1}{\varepsilon^2}} \tag{35}$$

The apparent time of a quasi-static DEMS with $\beta \approx 0$, for each other observer in motion able to interacting with one of the two particle of the bubble the Equation (34) can be rewritten as $t' = \gamma t$ in agreement with time dilation effect for the apparent time of the observer in motion.

6. Spontaneous Quantum Fluctuations in Action Value at Zero Point Energy

Since from Equation (26) the proper time of the DEMS is $T > 0$, to satisfy the invariant (30) it is sufficient that the relationship $T = h/E$ is satisfied with two possible equivalent solutions, one with positive action $+h$ and positive energy, one with negative action $-h \equiv \bar{h}$ and negative energy, the remaining solutions have no physical meaning. Therefore the proper time of the DEMS is positive and consequently the frequency ν of the photon is positive in these two cases

$$0 < \nu = \begin{cases} \dfrac{E}{h} & E > 0,\ h > 0 \\[2mm] \dfrac{\bar{E}}{\bar{h}} & E < 0,\ h < 0 \end{cases} \tag{36}$$

As demonstrated in Ref. [5], the change in sign of the value of the Planck action is due to the physical exchange of position of the interacting charges on the dipole axis, that is, by the different observation point of view of the observer that sees the interacting charges exchanged in position, that involves a measure of helicity with opposite sign. Consequently the Equation (36) defines the energy of a photon and of an anti-photon in terms of helicity with a positive action for a photon and a negative action for an anti-photon, both associate with a DEMS with positive proper time and frequency

$$\mathrm{E} = \begin{cases} E = h\nu \\ \bar{E} = \bar{h}\nu \end{cases} \tag{37}$$

According to Ref. [4], each of the two photons in Equation (37) is associated with a same potential energy of the vacuum with which they define the total energy of the bubble. The total energy written in a general form is

$$U = \mathrm{E}\left(1 + \frac{hc^5}{G_0}\frac{\operatorname{sgn}(\mathrm{E})}{\mathrm{E}^2}\right) \tag{38}$$

Where the second term is the potential energy of vacuum, *i.e.*, the energy of the nothingness field.

The value of the gravitational constant of a primitive bubble $G_0 = 8.68 \times 10^{+21}$ $\mathrm{kg^{-1} \cdot m^3 \cdot t^{-2}}$ has been carefully defined and estimated in Ref. [4]. Using Equation (37), the Equation (38) can be rewritten in the two different formulations

$$U = \begin{cases} E\left(1 + \dfrac{hc^5}{G_0}\dfrac{1}{E^2}\right) & \mathrm{E} > 0 \\ \bar{E}\left(1 - \dfrac{hc^5}{G_0}\dfrac{1}{E^2}\right) & \mathrm{E} < 0 \end{cases} \tag{39}$$

Requiring that the initial total energy of the vacuum be zero, to obtain a spontaneous creation of a pair photon, anti-photon, only the second formulation (39) associated at the anti-photon $\bar{h}\nu$ can originate a pair with zero total energy. Then, imposing $U = 0$ in Equation (39) only the second equation gives a fluctuation of energy with real values at Zero Point Energy (ZPE), the emission of a pair of particles with energy in the form anti-photon, photon $(\bar{h}\nu, h\nu)$ is expected. According to the Equation (39) it is possible to consider the anti-photon associated with the energy of the DEMS at first term of the second equation and the photon associated with the potential energy of the vacuum at the second term. In this case three conservation laws are respected:

(i) null total energy of vacuum

$$\bar{h}\nu + h\nu = 0 \tag{40}$$

(ii) null total momentum

$$\bar{\hbar}\boldsymbol{k} + \hbar\boldsymbol{k} = 0 \tag{41}$$

(iii) null total action

$$\bar{h} + h = 0 \tag{42}$$

The above conditions can be summarized using only the latest of the three that describes a zero-sum quantum fluctuation of the action value, where the presence of Planck's constant and of its anti-value are in BT the signature of the existence of direct interactions between pairs of polarized particles in motion along the dipole axis of their DEMS.

To show that a pair of bosons is produced in the form of an anti-photon photon as described in Equation (40), the Equation (38) being for Equation (37) $\bar{E} = \bar{h}\nu = -h\nu$, can be solved as a function of energy under ZPE conditions

$$\mathrm{E} + \frac{hc^5}{G_0}\frac{\operatorname{sgn}(\mathrm{E})}{\mathrm{E}} = 0 \tag{43}$$

Obtaining real numerical solutions of the energy (37)

$$\mathrm{E} = \pm\sqrt{\frac{hc^5}{G_0}} = \pm 2.68\ \mathrm{TeV} \tag{44}$$

These solutions correspond to a pair of Planck boson anti-bosons (PB), with mass energy 2.68 TeV, helicity ±1 and opposite momentum along a same emission axis (see **Table 1**). Each boson in agreement with DEMS description is rewritable in the photon form with a positive frequency

$$\nu_P = \sqrt{\frac{c^5}{hG_0}} \tag{45}$$

satisfying the ZPE requirements (40) and (41)

$$\bar{h}\nu_P + h\nu_P = 0 \tag{46}$$

and consequently, the requirement (42).

7. Properties and Structure of the Space-Time Bubble

The MBU model describes vacuum, energy and ordinary matter inside a primordial universe how emerging from a foam of spacetime formed by tiny bubbles, each bubble is an original DEMS formed by the creation and emission of a pair of primitive charged leptons at the energy limit of the Planck scale of which an estimate will be given. These leptons can be considered particles not yet diversified in the leptons of the Standard Model, here they are referred to as aleph particles ($\aleph^\pm$), whose electromagnetic field gives rise to the spacetime of the bubble of which the Equation (30) describes the relativistic invariant.

Considering a DEMS, *i.e.*, a single bubble of spacetime, its boundary is the surface of the wavefront emitted by the dipole, its total energy U is defined by Equation (38) as sum of the characteristic quantum energy of the DEMS and of the potential energy of the vacuum. As the emitted particles move away from each other, the interaction distance of the emitted pair of particles increases by

Table 1. The Planck boson P_0 and the Balancing graviton G_{BG} are two identical particles with two different roles in the universe formation and expansion.

Planck Boson	$E_P = \sqrt{\frac{hc^5}{G_0}}$	Helicity	$\lambda_P = \sqrt{\frac{G_0 h}{c^3}}$	$\nu_P = \sqrt{\frac{c^5}{hG_0}}$
P^0	4.29×10^{-7} J 2.68 TeV	+1	4.62×10^{-10} nm	$6.49 \times 10^{26}\ \mathrm{s}^{-1}$
$\bar{P}^0$	4.29×10^{-7} J 2.68 TeV	−1	4.62×10^{-10} nm	$6.49 \times 10^{26}\ \mathrm{s}^{-1}$

reducing the quantum energy of the DEMS but increasing the potential energy of the vacuum.

The electromagnetic energy inside the bubble is not a stable fixed value but can increase due to spontaneous random fluctuations that increase the total action value H of the bubble by an amount $H=(n-1)h$ with $n \geq 1$. As predicted by the MBU model, even in the presence of fluctuations the energy of the bubble is kept constant by the emission of an adequate number of BG (G_{BG}) which have the task of reducing the excess of electromagnetic quantum energy by transforming it into potential vacuum energy which is called the field of nothingness. The emission of G_{BG} reducing the energy of the DEMS and increasing the potential energy of the vacuum stretches the wavelength by dilating spacetime and increasing the redshift of the bubble.

7.1. The Balancing Graviton and the Planck Boson, Two Aspects of the Kaluza-Klein Graviton

The characteristics of mass and energy of the PB as exposed in **Table 1** are identical to one of a G_{BG} examined in Ref. [4], that is $E_{BG}=E_P$ but the PB have a different role respect the G_{BG}. In fact, PB give rise to new space-time bubbles, which can be considered the expansion cells of the universe, the balancing graviton has instead the role to balance the total energy U of the spacetime; "balancing" because its emission has the effect of keeping the total energy of the spacetime unchanged by reducing the amount of electromagnetic energy of the bubble, increasing the extension and the tension of space-time fabric, "graviton" because if the total energy of the vacuum in Equation (38) is lower than 7.55 TeV no G_{BG} are emitted (*i.e.*, $N=0$, cf. **Figure 2**). In this case the natural stretching of the wavelength of the DEMS due to the progressive removal of the pair of particles emitted during the growing of the bubble transforms the electromagnetic quantum energy into gravitational energy by the action of a typically Newtonian gravitational force.

As shown in Ref. [4], spontaneous fluctuations in the action value of the DEMS with $n \geq 1$ produce a vacuum energy $U=2E_{BG}\sqrt{n}$. If the number of fluctuations is $n \geq 2$, a number $N \geq 1$ of instantaneous adiabatic transitions with the emission of G_{BG} increasing the vacuum potential energy occurs, keeping the total energy U unchanged. In fact, each transition transfers an adequate number of gravitons from the electromagnetic energy to the potential energy of the vacuum, reducing the electromagnetic energy of the DEMS of an amount $\delta E=-2NE_{BG}$ and increasing simultaneously the potential energy of the vacuum by an identical amount $\delta W=2NE_{BG}$.

It can be noted that the positive solution of the energy (44) if used in the first of the two equations (39) provides the total energy of the vacuum ground state

$$U_0=2\sqrt{\frac{hc^5}{G_0}}=5.36\ \text{TeV}\ . \tag{47}$$

Equation (47) corresponds to the minimum total energy of a bubble of spacetime

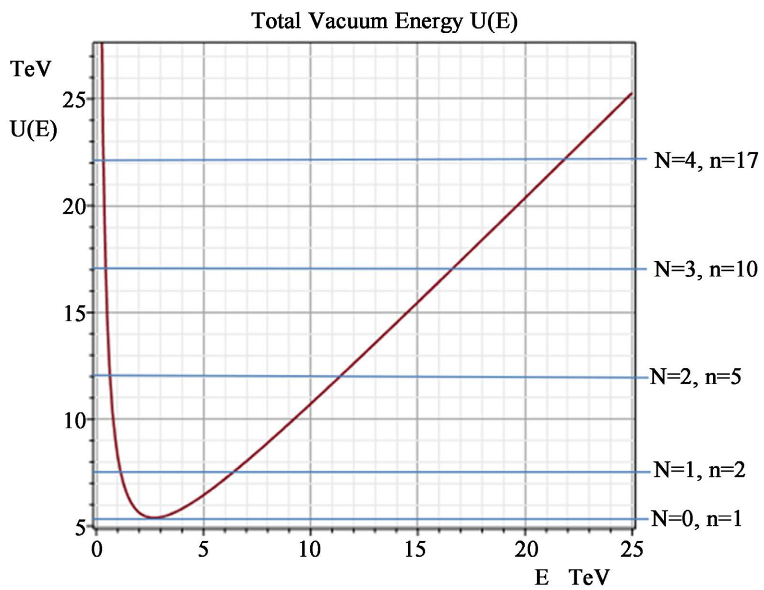

Figure 2. Total energy of the vacuum U as a function of the electromagnetic energy E of the DEMS. For electromagnetic energy values greater equal than E = 6.46 TeV obtained for a number of quantum fluctuations greater than n = 2, the emission of an adequate number N of gravitons reduces the electromagnetic energy of the bubble to values less than the energy of a graviton 2.68 TeV, by increasing the potential energy of the vacuum, dilating the spacetime and maintaining unchanged the total energy of the vacuum U.

generated by a quantum fluctuation $n = 1$. In this case the bubble has stable fixed energy equal to two Planck boson, no G_{BG} are emitted and the spontaneous stretching of the wavelength of the DEMS transforms the electromagnetic energy in Newtonian gravitational energy. Vice versa if the number of quantum fluctuations is $n \geq 2$, the total energy of the bubble increases with $U \geq U_0$ than the DEMS emits G_{BG} by transferring energy from the electromagnetic field to the potential energy of the vacuum to reduce the total amount of quantum electromagnetic energy to a value less than or equal to 2.68 TeV, a way to recycle excess electromagnetic energy that feeds the vacuum potential by providing it with the ability to produce new pairs of Planck bosons. In this process the zero vacuum energy state remains unchanged.

Although the reference model used here is the electromagnetic BT, it is important to note that the estimated energy of the graviton G_{BG} or identically of the Planck boson P_0 coincides significantly with the resting mass energy of the lighter Kaluza-Klein graviton, usually G_{KK}, proposed in Ref. [11], and it is in agreement with the experimental observed mass energy limit of 2.68 TeV as reported in Ref. [12] for a dilepton channel decay with a coupling parameter $k/\bar{M}_{Pl} = 0.1$ in the Randall-Sundrum model and with successive measures [13]. The BT can be considered in this case a different way to approach to this peculiar graviton and understand its role in nature to produce spacetime and matter.

7.2. P_0 Decay and Formation of a Pre-Universe

Considering a quantum fluctuation at ZPE conditions, Equation (46) describes the emission of a pair of Planck bosons ($P^0\bar{P}^0$) in the form of two real indistinguishable photons, each capable of decaying into a pair of unknown heavy particles, with lepton characteristics according to the channel $P^0 \to \aleph^+ + \aleph^-$ producing an equivalent DEMS of characteristic frequency (45).

By using the ratio $\zeta_{BG} = \lambda_{BG}^2 / \lambda_{ave}^2$ introduced in Ref. [4] as value of threshold separating the antigravitational zone of the DEMS within the redshift range $0 < z \le \zeta_{BG}$ from the gravitational zone with $z > \zeta_{BG}$ and assuming λ_{ave} as the average wavelength referred to a population of DEMS produced by the P^0 decay considered as a gas of virtual photons in a MBU, for a population of P^0 in the decay state, *i.e.* in equilibrium with their DEMS of energy $h\nu_P$ identical to that of a G_{BG} is true that: $\lambda_{ave} = \lambda_P \equiv \lambda_{BG}$, *i.e.* the threshold has value $\zeta_{BG} = 1$. Therefore, no fluctuation of action of the DEMS can increase its electromagnetic energy because this would require more energy than a PB could provide, then in general for fluctuations in the value of action such that $\lambda < \lambda_P$, instantaneous adiabatic transitions as described in Ref. [4] occur and the DEMS transfer one or more G_{BG} to the own vacuum potential energy by reconducting the wavelength of the DEMS to the case $\lambda > \lambda_P$.

If the value of redshift of the DEMS produced by P^0 decay is in the range $0 < z = \lambda/\lambda_P - 1 \le 1$ the antigravitational zone has wavelength range $\lambda_P < \lambda \le 2\lambda_P$, in this case the DEMS is produced by a pair of leptons that emerge from decay moving away from each other at superluminal speed, increasing the distance of mutual interaction, quickly stretch the original wavelength of the DEMS. For $z > 1$ with $\lambda > 2\lambda_P$ the DEMS is located in the Newtonian gravitational zone, where each DEMS loses energy gravitationally slowing down the emitted leptons. In the gravitational zone the emitted leptons are in a bound state, continuing to increase their interaction distance and reducing the internal electromagnetic energy of the DEMS, whose expanding wavefront widens the spacetime of the bubble. The removal of energy from the initial value of the PB feeds the gravitational energy that binds them.

Equation (46) describes the possibility of producing an unlimited number of pairs of PB originating from the field of nothing without the need for external energy contributions. The production of PB gives rise to a population of neutral non-interacting bosons, *i.e.*, disconnected from each other as they are positioned outside the spacetime at a null absolute electromagnetic temperature. This scenario describes the pre-universe, formed only by P^0. Spacetime, electromagnetic field, energy and matter cannot yet exist until their decay begins.

Considering the decay of each P^0 in a DEMS with wavelength $\lambda > \lambda_P$, being that the lack of electromagnetic field implies the lack of spacetime and an absolute temperature of the pre-universe equal to zero, the population of bosons of the pre-universe can be considered in a state similar to a Bose-Einstein condensate which description is not specific topic of this work. The condensate is not observable because it is generated at a distance less than or equal to r_0 , under the space-time horizon. The set of DEMS produced in the condensate decay behaves like a photon gas in thermal equilibrium with the emitted leptons that produced them.

The corresponding Planck energy distribution expressed as a function of wavelength in the antigravity zone $\lambda_P \le \lambda \le 2\lambda_P$ is given by

$$E\left(\lambda, \lambda_P\right) = \frac{hc}{\lambda\left(e^{\lambda_P/\lambda} - 1\right)} \tag{48}$$

Since, each boson P^0 before decaying it must become a virtual DEMS, the bosons can be considered a dual metastable object oscillating equiprobably between two energetically equivalent states, that of particle and DEMS: $P^0 \rightleftarrows \text{DEMS}$. When a P^0 enters the DEMS state it can decay in a pair of virtual aleph leptons $\aleph^{\pm}$ whose direct electromagnetic interaction produces an expanding DEMS, with an increasing wavelength and an expanding space-time volume, converting part of its internal electromagnetic energy into gravitational energy. Therefore, considering a very large number of decays, these gradually transform the P^0 population into the gas of virtual zero-spin photons emitted in the exchange of energy and momentum between the pairs of leptons. The gas is described by the energy distribution (48), the energy spectrum in the antigravitational zone is shown in **Figure 3(a)** and **Figure 3(b)**, its behavior in the gravitational zone for $\lambda > 2\lambda_P$ is described in **Figure 3(c)**. In this case the maximum diameter of the bubble can be infinite but de facto is bounded by the maximum redshifted value of the Planck boson and the upper value of the energy of the Planck spectrum becomes equal to the energy of the P^0 as shown in **Figure 3(c)**.

7.3. Emission of Leptons at the Upper Limit of the Planck Scale

ZPE conditions (40)-(42) and energy ground state (47) ensure that when a

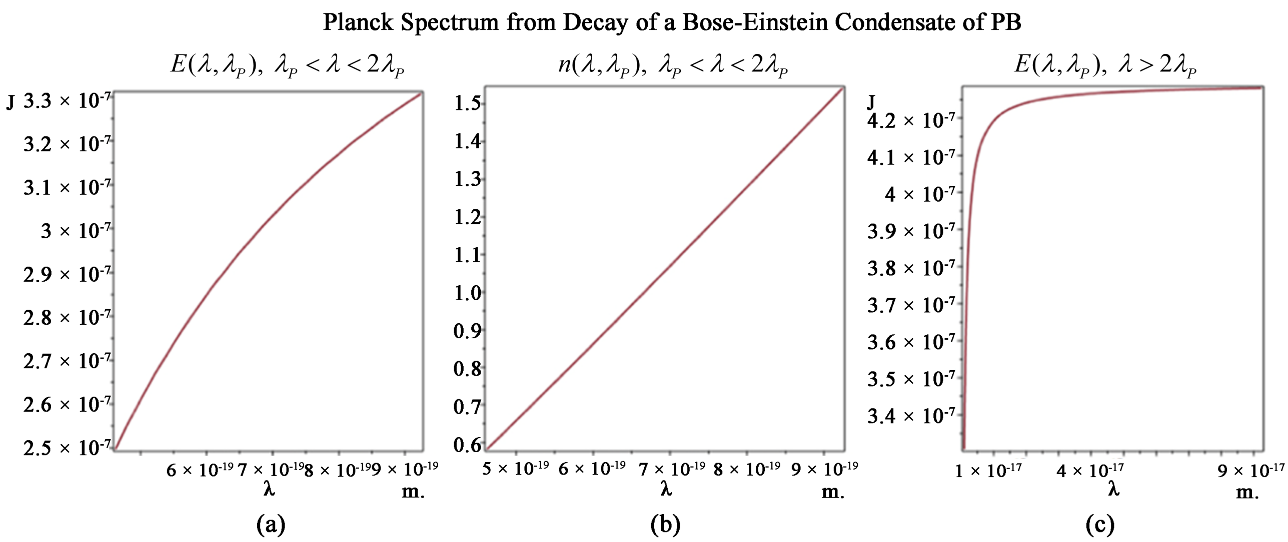

Figure 3. For a primordial population of isolated PB with $\zeta_{BG} = 1$, the energy emission (a) in the antigravitational zone can occur within the interval $\lambda_P \le \lambda \le 2\lambda_P$ at 2.97×10^{-7} J where the decay of a PB yields a maximum integer $n = 1$ (b) of spacetime bubbles, whose wavelengths grow rapidly due to the mutual removal of the emitted particles by entering the bubbles in the gravitational zone $\lambda > 2\lambda_P$ (c) by achieving the upper limit energy of 4.29×10^{-7} J corresponding to an initial universe temperature of 3.11×10^{16} K.

spontaneous emission of a pair of P^0 in the form (46) occurs inside a pre-existing bubble of spacetime, during their decay into two DEMS, two new space-time bubbles are generated, growing the pre-existing spacetime and increasing the amount of matter inside. This implies that the decay of the P^0 into pairs of leptons in spacetime can be detected with a minimum waiting time for an observer that according to Equation (31), considering a distance from the origin of the DEMS equal to own wavelength $r = \lambda \geq 2\lambda_P$, is greater than $\tau_{decay} = \sqrt{5}T_P$ equal to 3.44 × 10^{-27} s. After this delay time, the emitted lepton pair becomes visible emerging at a mutual distance of the order of 2 × 10^{-3} fm. Hence the decay of the PB through the DEMS does not occur from a real vertex, but considering the experimental detection with respect to an observer, the emission of leptons can be considered as having a vertex point. The two emerging interacting leptons have a total energy less than or equal to that of a PB. Following Ref. [6] the energy of the DEMS is

$$E_P = \sqrt{\frac{hc^5}{G_0}} = 2\gamma m_{\aleph} c^2 \tag{49}$$

In order to estimate the rest mass of each of the two emerging particles it is necessary to consider that for the electromagnetic structure of DEMS, at the time of their emission the two leptons are placed at a mutual diametral distance equal to the de Broglie wavelength of P^0. The particles emitted in the decay of the boson emerge in the same position that the particles would have in case of annihilation. Whether in the case of creation or annihilation, the associated DEMS is formed by the direct interaction between particles with equal rest mass and charge. As suggest in Ref. [5], in the position where the particles are located and the emission speed of each particle with respect to the center of mass of the DEMS coincides with that of propagation of the electromagnetic field, the pair of leptons $\aleph^{\pm}$ has an average speed with respect to the center of mass of the DEMS equal to $\beta_{\kappa} = u_{fin}/c$ with an estimated $u_{fin} = c/\pi$. Using Equation (49), at the moment of the decay the rest mass energy of each particle is the maximum value of Planck scale energy that can be emitted

$$m_{\aleph} c^2 = \frac{\sqrt{\pi^2 - 1}}{2\pi} \sqrt{\frac{hc^5}{G_0}} \tag{50}$$

equal to 1.27 TeV.

The mass energy (50) is equal to the maximum value in the Planck scale in accordance with the measured value at 95% of CL by the $D\varnothing$ collaboration in Ref. [14], where the particle emerging by the collision $p\bar{p}$ at $\sqrt{s} = 1.96$ TeV is recognized to be a high-energy lepton.

8. Cosmic Microwave Background of a Current Multi-Bubble Universe

By considering that the average wavelength of the gas of photon-DEMS obtained by the decay of the pre-universe is such a that $\lambda > \lambda_P$ with a threshold between the antigravitational and gravitational zone with a value $\zeta_{BG} < 1$ increasing the extent of the gravitational zone with respect to the antigravitational one and limiting the gravitational constants ratio at a value $Z < 1$, for the wavelength of the DEMS of energy $E = hc/\lambda$ satisfying the condition to be in the gravitational zone, *i.e.*, $z > \zeta_{BG}$ and have a wavelength larger than its Schwarzschild radius $\lambda > 2ZG_0 E/c^4$, DEMS survive temporarily by feeding the virtual photon population into thermal equilibrium with lepton pairs emitted during PB decay by generating a Planck blackbody spectrum that emulates the cosmic microwave background radiation (CMB) of our universe. The set of constraints previously defined are:

$$\begin{cases} \zeta_{BG} < 1 \\ z > \zeta_{BG} \\ \lambda > 2\dfrac{ZG_0}{c^4}E \\ Z < 1 \end{cases} \tag{51}$$

Giving

$$\begin{cases} \lambda^2 - \lambda_P^2 > 0 \\ \dfrac{\lambda^3}{\lambda_P^3} - \dfrac{\lambda^2}{\lambda_P^2} - 1 > 0 \\ \lambda > \sqrt{2Z}\lambda_P \\ Z < 1 \end{cases} \tag{52}$$

i.e.,

$$\begin{cases} \lambda > \lambda_P \\ \lambda > 1.46557\lambda_P \\ \lambda > \sqrt{2Z}\lambda_P \\ Z < 1 \end{cases} \tag{53}$$

with final solution $\lambda > 1.46557\lambda_P$ greater than the Schwarzschild radius of the DEMS.

Since the fundamental definition given in Ref. [4] of the ratio of the gravitational constant is

$$Z = \frac{G}{G_0} = \frac{1}{2}\left(z + \zeta_{BG}\right)\left(1 + b\right), \tag{54}$$

where $b = \beta\sin\varphi$ is the projection of the velocities of the particles emitted in opposite directions with an angle of 180˚, therefore with value $b = 0$. By making explicit the redshift in Equation (54) as $z = 2Z - \zeta_{BG}$, to estimate its value in the initial phase of the bubble, using the solution (53) one can estimate the redshift that satisfies it as $z < 1$. Since each DEMS is a virtual photon, considering the gas of DEMS within the volume of the spacetime associated to the electromagnetic foam, all photons that have a wavelength according with the solution (53) contributes to a blackbody radiation with a minimum of wavelength $\lambda_{\min} = \sqrt{2Z}\lambda_P$ and a maximum due to the redshift $\lambda_{\max} = (z+1)\lambda_P$.

Considering the intensity of the Planck spectrum as a function of the frequency $X = \lambda^{-1}$, from the definition of redshift z for an average wavelength obtained by stretching the wavelength of the Planck boson, a peculiar feature of the blackbody spectrum of the DEMS gas is obtained, *i.e.*: $\lambda_{ave} \equiv \lambda_{\max}$, that yields

$$u(X, z) = 2hc \frac{X^3}{e^{(z+1)\lambda_P X} - 1} \tag{55}$$

with frequency limited to the interval $\lambda_{\max}^{-1} < X \le \lambda_{\min}^{-1}$.

As an example, the resulting radiance (55) of a blackbody spectrum in units of megajansky per steradiant (MJy·sr^{-1}) is shown in **Figure 4(a)** for a young multi-bubble universe with a redshift $z = 15$, whereas in **Figure 4(b)** is presented the theoretical prediction for the blackbody spectrum of the gas of DEMS for an ancient multi-bubble universe considered at the temperature of the current CMB

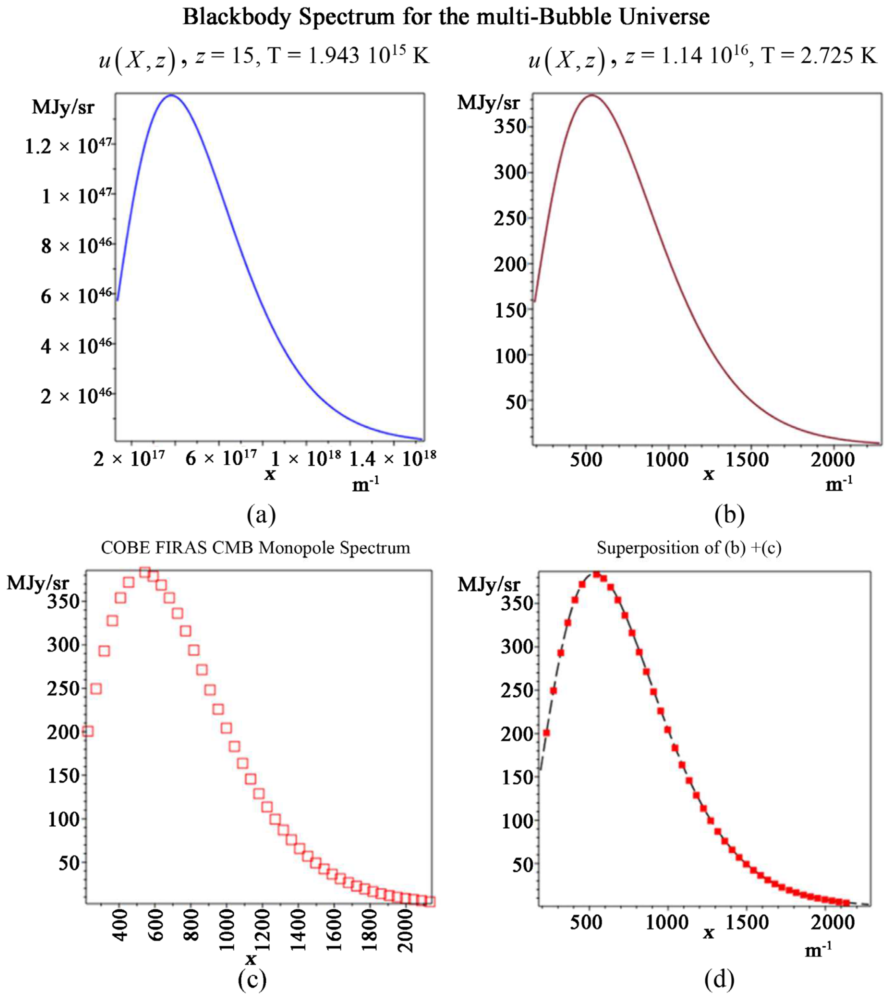

Figure 4. The spectrum (a) is obtained for a redshift z = 15 when the bubble has a radius whereas the spectrum (b) is obtained for $16\lambda_P$ when the bubble has a radius 5.27×10^{-3} m corresponding to the spectrum of the CMB. In (c) is shown the CMB COBE – FIRAS spectrum and in (d) is shown the agreement between the CMB data and the blackbody spectrum predicted by the model.

of 2.725 K with a redshift $z = hc/k_b T_{CMB} \lambda_P - 1$ estimated from the temperature measured from the data collected by the FIRAS antenna during the COBE mission (cf. Ref. [15] [16]) to be $z = 1.14 \times 10^{16}$.

The original CMB spectrum obtained from the FIRAS antenna is presented in **Figure 4(c)** and in **Figure 4(d)** is compared with the blackbody spectrum of the DEMS gas of **Figure 4(b)**. Considering the frequency constraints of the model, it is evident that the monopolar spectrum FIRAS fits perfectly with the theoretical prediction of the multi-bubble universe.

9. Conclusions

In the context of the Bridge theory developed in Ref. [7] [8] and [9] and expanded in the Ref. [5] [6], it has been shown that the hypothesis of a multi-Bubble Universe model (MBU) presented in Ref. [4], based on the existence of space-time bubbles emerging from the quantum-relativistic properties of the Dipole Electromagnetic Source (DEMS), is largely supported by four objective experimental facts.

The relativistic invariance of the period of a DEMS produced by the decay of a Planck boson, equivalent to a Balancing Graviton (G_{BG}) whose existence is predicted by the MBU model, is satisfied by its electromagnetic and quantum properties.

The existence of Planck bosons finds experimental foundations in the mass energy measurements of the Kaluza-Klein graviton 2.68 TeV, whose value corresponds to those theoretically estimated for G_{BG}. Its existence would then allow the transformation of excess electromagnetic energy in DEMS into new space-time and matter, a form of energy recycling that affects the expansion of the universe.

The experimental measurement of the upper limit of the Planck scale of 1.27 TeV, corresponds to the estimated value for the mass energy of the particles assumed to be emitted during the formation of space-time bubbles, corresponding to that of the $\aleph^{\pm}$ leptons emitted in the decay of the Planck boson.

The prediction of Planck radiation for an ancient multi-bubble universe at 2.725 K agrees with the measurements obtained for the CMB of our universe.

These peculiarities of the space-time bubble allow it to be attributed the role of germ of the multi-bubble universe, an elementary piece of an infinite puzzle.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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