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Quantum Klein-Gordon Equation of a Bosonic Particle in an Expanding Volume: CMB Photon Predicts the Age of the Universe (76.4 Gy) and the Observed Age (13.8 Gy) with Special Relativity

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Abstract

A few years ago, a model of the universe was presented in this journal. At that time, an age of 76.1 Gy had been found by hypothesizing that the CMB photons were the source of the observed Casimir effect. However, no explanation had been proposed for the fact that we were observing a much smaller age, about 13.8 Gy. In this paper, we demonstrate again by a completely different method, namely the solution of the Klein-Gordon equation for a bosonic particle undergoing a quantum expansion of space (Hubble-Lemaître law) that the age of the universe is indeed 76.4 Gy and we observe a shorter age by the effects of the special relativity generated by the relative speed of our galaxy with that of the CMB rest frame. Thus, we clearly demonstrate that the notion of time in the universe is indeed relative as predicted by the theory of special relativity. This could call into question certain notions involving distances and associated times in the universe.

Keywords

Cosmological Parameters Numerical Values, Cosmology Early Universe, Universe Age, CMB Photon, Klein-Gordon Equation, Special Relativity Application

1. Quantum Evolution Approach of Space and Time

In this same journal, a few years ago, a quantum approach to the evolution of time, space and energy (generation of photons) coupled with an equation of state that retained all the infinitesimal terms had made it possible to build a relatively complete model of the universe that would explain relatively well several observations that raised questions such as the non-Keplerian rotation of galaxies or the Hubble tension [1]-[3]. However, this approach has received very little interest to date. The reason is probably that the model is not in direct agreement with the ΛCDM model. However, since the surprising observations of the JWST, it must be admitted that our standard model of cosmology has some difficulties in interpreting observations. From this model of universe, here are the main conclusions or proposals:

1) The origin begins with the generation of photons number N at each q quantum of time t_{Planck} (cosmic time $t = qt_P$) according to a geometric progression.

$$N\left(qt_P\right) = \frac{8\zeta(3)}{3\pi}\left(\frac{2\pi k_b T_{CMB}}{hc}\right)^3 \left[\frac{\left(-cT_p t_U\right)qt_p - \left(l_p T_p t_U\right)}{\left(-T_p\right)qt_p - \left(t_U T_{CMB}\right)}\right]^3$$

with t_U, the age of the universe, T_P, Planck temperature, t_P, Planck time, T_{CMB}, observed CMB temperature.

At first, one photon and then for 10^{-9} s, a generation of 10^{89} photons ($U_{total} = 10^{98}$ J). The beginning, called Slow Bang SB, excludes an almost infinite energy singularity of the BB by the quantum generation of energy and space.

2) The problem of the event horizon finds a causal solution between the quantum generation of energy in phase with the quantum expansion of space at almost constant temperature and pressure, Planck's era (T_P and P_P).

3) An age of the universe of about 76,098 Gy was obtained with the assumption that the energy of the CMB photons is the source of the observed Casimir effect (Casimir force) and with the observed age of 13.8 Gy. However, in this first model, no explanation had been given as to why we observe a much shorter age of about 13.8 Gy. In this article, we will give a complete explanation using the special relativity and the Lorentz transformation.

4) The cosmological constant Λ is a function of time (H):

$$\Lambda(H) = 2.88\times10^{17} H^4 - 8.24\times10^{-2} H^3 \left[\mathrm{m}^{-2}\right]$$

with $H\left(s^{-1}\right)$ (at $t_U = 13.8$ Gy, $H = 67.4 \frac{\frac{\mathrm{km}}{\mathrm{s}}}{\mathrm{Mpc}} = 2.184\times10^{-18}\ \mathrm{s}^{-1}$).

It is used as the expression of the colossal energy of the photons in the tensor T^{00} of the GR equation.

5) This energy, expressed by Λ allows us to express a force F_Λ called cosmological by the mass-energy equivalence. The Newtonian limit is:

$$\Phi(r,t) = -\frac{Gm}{r} + \frac{c^2\Lambda(t)r^2}{12}$$

$$F_\Lambda(r,t) = \frac{\Lambda(t)}{6}c^2 rm = G\left(\frac{16\pi\sigma T_{CMB}^4 t_U^4}{3c^3}\right) mrH^4$$

with m the mass of the object (galaxy or BH).

This additional force explains the non-Keplerian rotation of several galaxies by adjusting the predicted velocities to that observed by this gravitational potential at the time t of the universe of the formation of this galaxy. This allows us to know the approximate beginning as well as the average time of the galaxy's formation.

6) We find that the formation of the studied galaxies is much earlier and the time of formation is much faster than the conventional estimates proposed by the conventional models (time delayed SFR bottom-up [4]). As an example, we find that the formation of the MW began around 180 My after the SB and the main formation was staggered over 320 My only. A very short period compared to the normally accepted period of several Gy. However, observations of distant galaxies by the JWST tend to confirm an abundant existence of galaxies comparable to MW before 0.5 Gy since the beginning [5].

7) From the shape of the curve of the measured rotation of barionic matter, it is possible to determine whether a galaxy was formed early in the universe ETG (<0.5 Gy concave shape) or later LTG (convex shape, Keplerian) [6].

8) From the definition of the Hubble-Lemaître law, we found that the value of the Hubble constant is a variable depending on the observed galaxy (transceiver pair with the MW). This explains the large variations in Hubble constant measurements from the smallest observable value CMB-MW pair (67.4 km/s/Mpc) to the largest values observed with a specific galaxy-MW pair [7].

2. Klein-Gordon Quantum (Quantization of Space and Time)

This idea of the quantization of space and time is not new as the LQG theory [8] [9]. Indeed, several approaches have already been proposed as for BH (LQBH) [10]. Of all these approaches, one difficulty remains, either the possibility of demonstrating this quantification experimentally because the values involved are extremely small beyond the measuring devices. As an example, a quantification of the order of the Planck era relates quantities of the order of 10^{-35} m, which is multiple orders lower than the smallest measurements made today, *i.e.* 10^{-18} to 10^{-20} m [11]. Lately, efforts have been made to demonstrate that gravity could be quantum in nature [12], but this has not yet been completely demonstrated. As for the Klein-Gordon equation (relativist Schrodinger equation), its expression is based on the concept of a continuous space and time by the nature of the expressions of the derivatives of the equation, although the energy of a system is quantum in nature. However, there is nothing to prevent us from making the assumption that this equation is based on an idea of the quantification of the quantities involved, *i.e.* the wave function, energy and *space and time*, and on the idea of the Z transform of this equation at the quantum scale. Thus, let be the time dependant Klein-Gordon equation in a conventional relativistic 3D Euclidean space written in the form of a differential equation.

$$-c^2\nabla^2\Psi+\frac{m^2c^4}{\hbar^2}\Psi+\frac{\partial^2\Psi}{\partial t^2}=0$$

with the wave function Ψ, the mass m of the particle.

For a time-invariant but spatially variable bosonic particle in the context of the expansion of the universe ($H > 0$), the K-G equation can be written as [13].

$$-\nabla^2\Psi + \frac{p^2}{\hbar^2}\Psi = 0$$

3. Expression of the Quantum K-G Equation (Discretized with Z-Transformed)

In order to find an expression for the quantum wave function of a particle undergoing space expansion, let us express the above equation using the Z transform which allows us to express a quantum variation (by increments q) of the space x denoted Δx.

$$\frac{-\left(\Psi(n+1) - 2\Psi(n) + \Psi(n-1)\right)}{\Delta x^2} + \frac{p^2}{\hbar^2}\Psi(n) = 0$$

$$\left[-\left(Z - 2 + \frac{1}{Z}\right) + \frac{\Delta x^2 p^2}{\hbar^2}\right]\Psi(Z) = 0$$

with $x(q) = q\Delta x$ et $q = 1, 2, 3, \cdots$ (integer).

Δx is the quantum space increment. We accept the smallest possible value for the moment, *i.e.* the Planck length l_P. In the above equation, if we assume the *necessary existence* of the wave function for this particle either ($\Psi(Z) \overset{\text{def}}{\neq} 0$), we find a quantum condition that expresses the momentum of this bosonic particle in the context of the expansion of space, or

$$\frac{\hbar^2}{p(Z)^2 l_P^2} = \frac{1}{Z - 1 + \frac{1}{Z}}$$

If we go back to the expression in the domain x with the inverse Z transform, we find for the momentum of this particle in the context of expansion.

$$p^2 = \frac{U^2}{c^2} = \frac{\hbar^2}{l_P^2}\frac{1}{q}$$

For the quantum energy of this particle in the context of expansion we find.

$$U = \frac{\hbar}{t_P\sqrt{q}} = \frac{E_P}{\sqrt{q}}$$

$$q = 1, 2, 3, \cdots$$

How should we interpret this result? We have admitted the existence of a bosonic particle which exists at the beginning and which undergoes an expansion of space ($H > 0$). The energy of this particle evolves with each quantum time increment t_P and it moves at the intrinsic speed c. The proper distance traveled by the particle is $r = ql_P$.

The space quantum wave function of this particle undergoing expansion that satisfies the K-G equation is Ψ:

$$\Psi(x) = \Psi(ql_P) = \frac{1}{\sqrt{ql_P}}\mathrm{e}^{ikx} = \frac{1}{\sqrt{ql_P}}\mathrm{e}^{(ikl_P)q} = \frac{1}{\sqrt{ql_P}}\mathrm{e}^{\left(\frac{2\pi i l_P}{\lambda}\right)q} = \frac{1}{\sqrt{ql_P}}\mathrm{e}^{2\pi i\frac{E_P^2}{U^2}\frac{l_P}{\lambda}}$$

or

$$\Psi(q) = \frac{1}{\sqrt{q}} e^{i\sqrt{q}}$$

with $q = 1, 2, 3, \cdots$

$$U(q) = \frac{E_P}{\sqrt{q}}$$

$$\lambda(q) = \frac{hc}{E_P}\sqrt{q}$$

If we accept the hypothesis of the quantization of space as well as the presence of a bosonic particle at the origin (spin 1), the wave equation obtained is remarkable since it predicts a quantum evolution of this particle in the case of an expanding universe. The following **Figure 1** and **Figure 2** show the wave function *x*, *y* and polar form of this particle (CMB photon).

$$\Psi(q) = \frac{1}{\sqrt{q}}\left(\cos\sqrt{q} + i\sin\sqrt{q}\right)$$

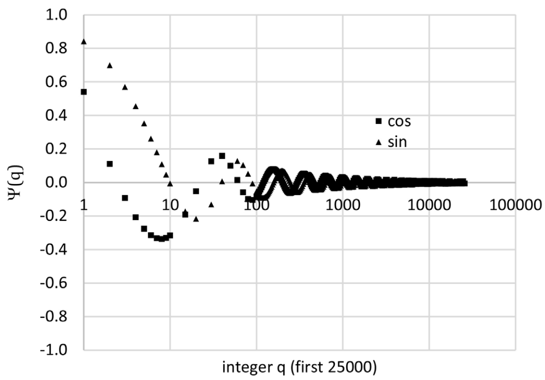

Figure 1. Wave function (quantum or discretized in space) of a CMB photon for the first q or $t = 25000t_p = 1.348 \times 10^{-39}$ s.

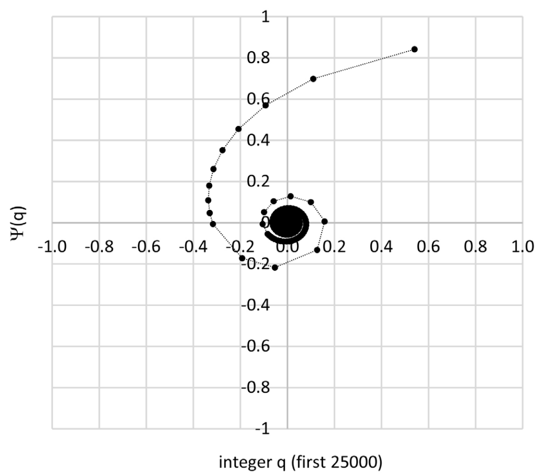

Figure 2. Polar form of the Wave function (quantum or discretized in space) of a CMB photon for the first q or $t = 25000t_p = 1.348 \times 10^{-39}$ s.

4. CMB Photon and the Expanding K-G Equation

If we assume that these bosonic particles from the beginning of the universe are the photons of the CMB, knowing the average energy of the photons today, we will be able to estimate the age of the universe. Indeed, the photons of the CMB correspond to a free quantum field formed of bosons and the average energy of the photons of the CMB at our space-time is for a gas of photons at the average temperature $T_{CMB} = 2.72548 \pm 0.00057\ \text{K}$ [14].

$$U_{CMB} = h\upsilon_{CMB} = \frac{hc}{\sigma_W / T_{CMB}} = 1.86834 \times 10^{-22} \pm 3.9 \times 10^{-26}\ \text{J}$$

Thus, the quantum number q associated with the photons of the CMB is

$$q_{CMB} = \frac{E_P^2}{U_{CMB}^2} = 1.0961 \times 10^{62} \pm 4 \times 10^{58}$$

The photons of the CMB have traveled a proper distance d, *i.e.*

$$r(q) = q l_P = 1.7716 \times 10^{27} \pm 7 \times 10^{23}\ \text{m}$$

In light years we find a dimension for the universe according to the photons of the CMB.

$$r_U = \frac{r(q)}{9.461 \times 10^{24} \left(\frac{\text{m}}{\text{Gy}} \right)} = 187.260 \pm 0.078\ \text{Gy}$$

With the assumption of the expansion according to the Hubble-Lemaître law for the entire universe $\dot{D}$ and an intrinsic constant photon velocity at *c*, we can determine an age of the universe with the initial condition $r(0) = r(q = 1) = l_p$, either:

$$\frac{\mathrm{d}D}{\mathrm{d}t} = Hr + c$$

$$\frac{\mathrm{d}r}{\mathrm{d}t} = Hr/2 + c$$

$$r(t) = l_P \mathrm{e}^{Ht/2} + \frac{c}{H}\left(\mathrm{e}^{Ht/2} - 1\right)$$

Thus, knowing the following values from the CMB

$$r_U = 187.260 \pm 0.078\ \text{Gy} \quad \text{(this study)}$$

$$H = 67.4 \pm 0.5 \frac{\text{km}}{\text{s}} \Big/ \text{Mpc} \quad [15]$$

We find this equation that expresses the age of the universe:

$$t_U = \frac{2}{H} \ln \left[\frac{r_U + \frac{c}{H}}{l_P + \frac{c}{H}} \right] = 76.433\ \text{Gy}$$

After some manipulation, we can find these equivalent equations.

$$t_U \cong \frac{2}{H}\ln\left[\frac{Ht_P\lambda_{CMB}^2}{(2\pi l_P)^2}+1\right]=76.433\text{ Gy}$$

$$t(z)\cong\frac{2}{H}\ln\left[\frac{H\lambda_{CMB}^2}{4\pi^2 c l_P (z+1)^2}+1\right]$$

In the equation above, we see an expression $2\pi l_P$ that could correspond to a dimension related to the circle or to a surface related to a sphere of dimension l_P. This can be reminiscent of the idea of a quantum loop or a quantum spin foam related to the circle at the origin (loop size, see Equation (10) in [16]). Also, in the equation that expresses the age of the universe as a function of the redshift z of the observed object, for $z \approx 1100$ (CMB), we find a universe age of $t_{CMB} \approx 310{,}000$ y, which is approximately the one estimated at the time of the emission of the photons peak of the CMB (≈372,000 y).

5. If the Age of the Universe Is 76.4 Gy, Why Do We Estimate and Measure an Experimental Value of 13.8 Gy?

The answer is obvious, the effects of special relativity. Here are the explanations. The two reference systems are ours, the MW (system unprimed), and the second, that of the CMB photons (system primed). Let's remember that the photons in the CMB come directly from a moment very close to the beginning (the Planck's era). Also, we assume that the effects of special relativity are mainly in the direction of expansion (1 − D, radius r) although much weaker relative motions exist between galaxies given gravity.

The known (measured) values are as follows (MW unprimed system):

$$t_{MW} = 13.73 \pm 0.15\text{ Gy} \cong 13.8\text{ Gy} = 4.35\times 10^{17}\text{ s} \quad [17]$$

$$v_{MW} = v_{CMB} - v_{LG} = v_{CMB} - \left(620 \pm 15\,\frac{\text{km}}{\text{s}}\right) \cong c - 630 \quad [18]$$

$$r_{MW} = \frac{c}{H}\left(e^{\frac{Ht_{MW}}{2}}-1\right) = \frac{2.99\times 10^{8}}{2.18\times 10^{-18}}\left(e^{\frac{2.18\times 10^{-18}\times 4.35\times 10^{17}}{2}}-1\right)$$

$$= 8.35\times 10^{25}\text{ m} = 2706\text{ Mpc}$$

We can estimate the values in the CMB (primed system) with Lorentz transformations and special relativity either:

$$t'_{CMB} = t_U = \gamma\left(t_{MW} - \frac{v_{MW} r_{MW}}{c^2}\right)$$

$$t'_{CMB} = t_U = \gamma\left(t_{MW} - \frac{(c - v_{MW}) r_{MW}}{c^2}\right)$$

$$t'_{CMB} = t_U = \gamma\left(t_{MW} - \frac{(c - v_{MW})\frac{c}{H}\left(e^{\frac{Ht_{MW}}{2}}-1\right)}{c^2}\right)$$

$$t'_{CMB} = t_U = \frac{1}{\sqrt{1-\frac{v_{MW}^2}{c^2}}}\left(t_{MW} - \frac{(c-v_{MW})\frac{c}{H}\left(e^{\frac{Ht_{MW}}{2}}-1\right)}{c^2}\right)$$

We find:

$$t'_{CMB} = t_U$$

$$= \frac{1}{\sqrt{1-\frac{(c-630000)^2}{c^2}}}\left(4.35\times10^{17} - \frac{(c-630000)\frac{2.99\times10^8}{2.18\times10^{-18}}\left(e^{\frac{2.18\times10^{-18}\times4.35\times10^{17}}{2}}-1\right)}{c^2}\right)$$

$$t'_{CMB} = t_U = 2.426\times10^{18}\ \text{s} = 76.933\ \text{Gy!}$$

We can find the distance of the CMB with the Lorentz transform again.

$$r'_{CMB} = \gamma(x_{MW} - v_{CMB}t_{MW}) = \frac{1}{\sqrt{1-\frac{v_{MW}^2}{c^2}}}\left(r_{MW} - (c-630000)t_{MW}\right)$$

$$r'_{CMB} = \frac{1}{\sqrt{1-\frac{(c-630000)^2}{c^2}}}\left(8.35\times10^{25} - (c-630000)4.35\times10^{17}\right)$$

$$= -7.204\times10^{26}\ \text{m}$$

$$r'_{CMB} = -76.933\ \text{Gy}$$

Also, we can find the age of universe from the MW with the inverse transform.

$$t_{MW} = \gamma\left(t'_{CMB} + \frac{v_{MW}r'_{CMB}}{c^2}\right)$$

$$t_{MW} = \frac{1}{\sqrt{1-\frac{v_{MW}^2}{c^2}}}\left(t_U + \frac{(c-v_{MW})(-7.204\times10^{26})}{c^2}\right)$$

$$t_{MW} = \frac{1}{\sqrt{1-\frac{(c-630000)^2}{c^2}}}\left(2.426\times10^{18} + \frac{(c-630000)(-7.204\times10^{26})}{c^2}\right)$$

$$= 4.351\times10^{17}\ \text{s}$$

$$t_{MW} = 13.8\ \text{Gy}$$

Calculating the invariant interval, we need to find the same value for the MW observer and the CMB observer.

$$\Delta s_{MW}^2 \overset{\text{def}}{=} c^2\Delta t^2 - \Delta x^2 = c^2\times4.35201\times10^{172} - 8.3515\times10^{252} = 1.004\times10^{52}\ \text{m}^2$$

$$\Delta s_{CMB}^2 \overset{\text{def}}{=} c^2\Delta t'^2 - \Delta x'^2 = c^2\times2.4262\times10^{182} - 7.2040\times10^{262} = 1.006\times10^{52}\ \text{m}^2$$

Either

$$\frac{\Delta s_{CMB}^2}{\Delta s_{MW}^2} = 1.001$$

A positive invariant interval means a time like separated (the MW is separated by more time than space from the CMB).

Several cosmological implications arise from this calculation. In fact, this completely changes how we perceive the notion of time in the universe. In the first place, on reflection, it is obvious that the perception of time in the universe is a function of the observer. Time is relative, each observer present within a galaxy will note a variable age of the universe but the real age, *i.e.* the proper time of the CMB photons, is 76.4 Gy.

6. Special Relativity Makes It Possible to Estimate Some Structures Parameters in the Universe According to the CMB Rest Frame

As an example, let's take M87. Several parameters are known from our position but with a fairly large variation. We cannot precisely determine the orientation of M87 according to the CMB and the MW. However, an observer located at M87 (in the past according to our observations) must find an age of universe compatible with this orientation or distance. Indeed, as we observe M87 in the past, we must subtract this past from the age of the universe as well as from the age of M87.

Using the invariants Δs^2 of the galaxy M87 and the CMB, that must be equal, we can estimate a velocity of M87 with respect to the rest frame of the CMB.

We know approximately:

$$d_{\odot}^{M87} \cong 53.5 \text{ My} \cong 16.4 \text{ Mpc} \quad [19]$$

$$v_{M87}^{MW} \cong (1282 \pm 9)\frac{\text{km}}{\text{s}} \quad [19]$$

To validate all the values used, we need to check the invariants. In addition, we observe M87 in the past, either.

$$t'_U \cong t_U - d_{\odot} \cong 76.933 - 0.0535 \cong 76.879 \text{ Gy} = 2.424 \times 10^{18} \text{ s}$$

After several trials and errors, we find the following value of v_{M87} (relative to CMB rest frame) which allows us to satisfy the invariants.

$$v_{M87} \cong c - 628.2$$

$$r'_U \cong -7.1980 \times 10^{27} \text{ m}$$

So for the universe age perceived by an M87 observer there is 54 My ago.

$$t_U^{M87} \cong \frac{1}{\sqrt{1 - \frac{v_{M87}^2}{c^2}}}\left(t'_U + \frac{(c - v_{M87})(-7.1980 \times 10^{26})}{c^2}\right)$$

$$t_U^{M87} \cong \frac{1}{\sqrt{1 - \frac{(c - 628200)^2}{c^2}}}\left(2.424 \times 10^{18} + \frac{(c - 628200)(-7.1980 \times 10^{26})}{c^2}\right)$$

$$= 4.334 \times 10^{17} \text{ s}$$

$$t_U^{M87} \cong 13.742 \text{ Gy}$$

For the distance

$$r_{M87} \cong \frac{c}{H}\left(e^{\frac{Ht_U^{M87}}{2}} - 1\right) \cong \frac{2.99\times10^{8}}{2.18\times10^{-18}}\left(e^{\frac{2,18\times10^{-18}\times4.334\times10^{17}}{2}} - 1\right)$$

$$r_{M87} \cong 8.307\times10^{25} \text{ m} \cong 2692 \text{ Mpc}$$

Let's check the invariants:

$$\Delta s_{M87}^2 \overset{\text{def}}{=} c^2\Delta t^2 - \Delta x^2 = c^2 \times 4.3336\times10^{172} - 8.3075\times10^{252} = 9.9779\times10^{51} \text{ m}^2$$

$$\Delta s_{CMB}^2 \overset{\text{def}}{=} c^2\Delta t'^2 - \Delta x'^2 = c^2 \times 2.4240\times10^{182} - 7.1980\times10^{262} = 9.9779\times10^{51} \text{ m}^2$$

Either

$$\frac{\Delta s_{M87}^2}{\Delta s_{CMB}^2} = 1.00$$

We see that the notion of time is relative to the observer. We find a gap between M87 and the MW of

$$\Delta r = r_{MW} - r_{M87} = 2706 - 2692 = 14 \text{ Mpc}$$

This value is close to the one measured (16 to 20 Mpc). In addition, by changing the value of the constant H slightly according to the uncertainty (±0.4), we can increase this value.

Another more extreme example is that of the very old ($z > 13$) and already very bright (massive) galaxies observed in large numbers by the JWST. Indeed, models of galaxy formation cannot fully explain how they formed so quickly with such a rapid generation of stars (high SFR). However, we saw in a previous article [6] that we can explain the formation of galaxies relatively well much faster by the addition of this cosmological force mentioned earlier.

Recently, one of these galaxies Jades-GS-z14-0 ($z = 14.32$) was observed and confirmed (Lyman-α breaks). Based on a model giving the age of a structure according to luminosity and redshift (back in time) [20], it is estimated that this galaxy was already in place, about 290 My after the beginning (unprimed observed age).

$$t_U(z) = \frac{2}{3H\sqrt{\Omega_m}}\frac{1}{(1+z)^{3/2}}$$

With $\Omega_m \simeq 0.3$ and $z = 14.32$, we find

$$t_{Jades}(z) \cong 13.8 - 13.505 = 0.290 \text{ Gy} = 9.145\times10^{15} \text{ s}$$

This estimated value of the age of Jades-GS-z14-0 can vary, but it certainly varies between 290 and 900 My with the general equation of redshift.

$$t_{Jades}(z) = 13.8\frac{1}{1+z} = 0.900 \text{ Gy}$$

Now, we can estimate the age of the universe (primed) at the time we observe this galaxy in the past (290 My). We need to estimate the relative velocity of this distant galaxy with the CMB rest frame. Several possibilities for calculating or estimating this relative speed are possible and determining this speed is not so simple. If we use the Hubble-Lemaître law which give a high relative speed.

$$v_{Jades} = Hr_{Jades} = c\left(e^{\frac{Ht_{Jades}}{2}} - 1\right) = 2.99\times10^{8}\left(e^{\frac{2,184\times10^{-18}\times9.145\times10^{15}}{2}} - 1\right)$$

$$\cong 3.00\times10^{6}\ \text{m/s}$$

We find for the age of the universe (primed) for this galaxy at the time we observe it.

$$t'_{CMB} = \gamma\left(t_{Jades} - \frac{(c - v_{Jades})r_{Jades}}{c^2}\right)$$

$$t'_{CMB} = 7.08\left(9.145\times10^{15} - \frac{(c - 3.00\times10^{6})\times1.377\times10^{24}}{c^2}\right)$$

$$t'_{CMB} = 3.2518\times10^{16}\ \text{s} = 1.02\ \text{Gy}$$

And

$$r'_{CMB} = \gamma\left(r_{Jades} - (c - v_{Jades})t_{Jades}\right)$$

$$r'_{CMB} = 7.08\left(1.3777\times10^{24} - (c - 3.00\times10^{6})\times9.145\times10^{15}\right)$$

$$r'_{CMB} = -9.4561\times10^{24}$$

We find that the age of the universe at the time we observe Jades-GS-z14-0 is about 1 Gy, which leaves much more time for the formation of this galaxy (proper time of the universe).

Calculating the invariant interval, we need to find the same value for the Jades-GS-z14-O observer and the CMB observer.

$$\Delta s^2_{Jades} \overset{\text{def}}{=} c^2\Delta t^2_{Jades} - \Delta r^2_{Jades} = c^2\times9.145\times10^{152} - 1.3777\times10^{242} = 5.6189\times10^{48}\ \text{m}^2$$

$$\Delta s^2_{CMB} \overset{\text{def}}{=} c^2\Delta t^2_{CMB} - \Delta r^2_{CMB} = c^2\times3.2518\times10^{162} - 9.4561\times10^{242} = 5.6189\times10^{48}\ \text{m}^2$$

Either

$$\frac{\Delta s^2_{CMB}}{\Delta s^2_{Jades}} = 1.00$$

7. Discussion and Main Conclusion

In this article, we have seen and calculated several cosmological quantities using two starting hypotheses:

1) The photons of the CMB have a quantum wave function with a quantum space and time that obeys the K-G equation. Photons undergo the expansion of the universe according to the Hubble-Lemaître law with H.

2) The notion of time in the universe obeys the law of special relativity. In reality, an acceleration exists for MW but it is not considered here. It is of the order of 2.5×10^{-13} m/s^2.

From these main hypotheses we found an age for the universe 76.4 Gy (proper time or cosmic time) and explained why we observe a shorter age (time relative to MW). Also, this value of the age of the universe corresponds to the one found a few years ago 76.1 Gy by assuming that the photons of the CMB are the cause of the observed Casimir effect.

A longer age for the universe makes it much easier to reconcile the JWSP's observations about very distant galaxies that have had much longer to form.

This notion of time relative to the observer in the universe makes the various interpretations relating to distances (redshift z, luminosity distance d_L, angular diameter distance d_A) much more difficult. Future developments will be necessary to interpret these notions with the concept of relative time according to the velocities of the observed objects. Indeed, the velocities are relatively low compared to c but the distances being very large as well as the age of the universe very large, the effects of special relativity become important.

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Conflicts of Interest

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

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