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Calculation of the Moment of the Beginning of the Existence of Light in the Universe

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Abstract

The apparent age of the universe is about $T \approx 13.56\times10^9$ years. Light is part of our everyday life, but it has not always existed. According to physicists, it began to exist about ~360 000 to 380 000 years after the Big Bang.

We calculated the exact moment of the appearance of light based on a new cosmological model shown in 2019. In this model, we make the following hypotheses: 1) The apparent radius of curvature of the universe increases at the velocity of light. 2) Our universe is in rotation on itself. 3) The tangential speed of the universe's periphery is the same as an electron. 4) Our universe is made of a ″material universe″ imbricated in a ″luminous universe″.

With Einstein's laws of relativity for spinning disks and the addition of speeds, we can establish the moment where the universe became transparent and emitted light. We evaluate that moment to ~361 108 years after the Big Bang.

The assumptions used for the calculations reveal some interesting facts about the structure and characteristics of our universe. This article may be a step-stone for other analyses.

Keywords: the beginning of the existence of light, transparency of the universe, adding speed vectors

1. Introduction

This article attempts to find an easy way to calculate the universe's age when the light began to exist. According to some sources, this moment occurred between ~360 000 years (Jenkins A., Villard R., and Riess A., 2018) to ~380 000 years (Turner M. S., 2009) after the Big Bang. Even if this moment is of capital importance to understanding our universe's genesis, no model seems appropriate to calculate precisely this moment. Nevertheless, the first moments modeled our universe and dictated some parameters of our universe. For example, we will see that the electron's spin is intimately linked to the tangential speed of the universe, which reigned at the time of the appearance of light.

Our study is theoretical and based on our previous research and model (Mercier C., 2019a). This model implies that the universe began as a very compact point-like pellet of matter. It was so dense at its beginning that we could not even distinguish the electrons. After ~360 000 years after the Big Bang, the luminous universe started its expansion (Hubble E., 1929). The universe's density was lower enough to give some freedom to electrons. Once they could shift level around their nucleus, they began to emit light. A vast sphere made of light began to envelop the primordial universe. We call this sphere the ″luminous universe″. This sphere is expanding at the speed of light (Macleod Alasdair, 2004). Since matter cannot travel as fast as light (Einstein A., 1905), it accumulates a delay that increases with time. According to our model, a second sphere, composed of matter, is in expansion at a rate that is a fraction β of the speed of light. This second sphere is called the ″material universe″. The β constant is unique to our model, and the material universe is imbricated in the luminous universe. Both spheres have the same origin, which corresponds to the center of mass of the universe.

In our previous study (Mercier C., 2019a, 2019b, 2020, and 2021), we hypothesized that the tangential speed of the universe was the same as an electron. However, we could not show why there was a link between these two. The present article improves our understanding of the universe. It shows the connection between the Lorentz factor associated with the tangential speed of rotation of the universe and the fine-structure constant α that prevails in an electron.

Our present study supposes the following hypotheses: 1) The luminous universe expands at the speed of light. 2) Our universe is spinning on itself. 3) The universe's periphery rotates with the same tangential speed as an electron. 4) Our universe is made of a ″material universe″ imbricated in a ″luminous universe″.

The tangential speed of an electron is relativistic since it is very close to the speed of light. Therefore, if our universe spins on itself with the same tangential velocity as an electron, we must consider the relativistic effect of this rotation. Furthermore, because of Einstein's spinning disk effects (Einstein A., 1912), the universe looks larger from an observer at rest. We will show that the Lorentz factor associated with the tangential speed of rotation of the universe may be related to the fine-structure constant that prevails in an electron.

Our present study will help evaluate the moment of the occurrence of light (which will be evaluated to ~361 108 years). On the side, it will also show that our universe is spinning on itself (Hawking S., 1969) (Fennelly A. J., 1976) like an electron (Llewellyn T., 1926) with all implied relativistic effects (Einstein A., 1912). It also highlights that the Lorentz factor may be associated with the fine-structure constant α for a few relativistic effects in our universe. The association between α and the Lorentz factor is corroborated by our model, which makes it possible to precisely calculate the temperature T of the CMB (Cosmological Microwave Background) in our universe. In the future, some other links with the moment of occurrence of light may be done to explain some particle characteristics.

2. Physics Parameters

2.1 Parameters from CODATA 2014 (Committee on Data for Science and Technology)

Even if it is not the most recent version, we recommend using the CODATA 2014 (Mohr P. J., Newell D. B., and Taylor B. N., 2016) to compare our new equations and results with our articles (Mercier C., 2019a, 2019b, 2020, and 2021). We prefer a compact notation to display tolerances (i.e., 2.734(10) °K means 2.734 ± 0.010 °K).

Light speed in a vacuum	$c = 299792458\ \mathrm{m{\cdot}s^{-1}}$
Planck's constant	$h \approx 6.626070040(81)\times10^{-34}\ \mathrm{J{\cdot}s}$
Fine-structure constant	$\alpha \approx 7.2973525664(17)\times10^{-3}$
Electron mass	$m_e \approx 9.10938356(11)\times10^{-31}\ \mathrm{kg}$
Classical electron radius	$r_e \approx 2.8179403227(19)\times10^{-15}\ \mathrm{m}$
Universal gravitational constant	$G \approx 6.67408(31)\ \mathrm{m^3{\cdot}kg^{-1}{\cdot}s^{-2}}$
Boltzmann's constant	$k_b \approx 1.38064852(79)\times10^{-23}\ \mathrm{J{\cdot}°K^{-1}}$
Stefan-Boltzmann's constant	$\sigma \approx 5.670367(13)\times10^{-8}\ \mathrm{W{\cdot}m^{-2}{\cdot}°K^{-4}}$

2.2 Equations and Parameters From a Previous Model

We want to focus on calculating the moment of the first occurrence of light in our universe. Therefore, we do not wish to reexplain our model's details and results (Mercier C., 2019a, 2019b, 2020, and 2021). Instead, we will take some equations and results from the model described in our previous articles. These equations may be relatively new for most readers. Therefore, we strongly urge these to read these related articles.

In 2019, we presented a new cosmological model (Mercier C., 2019a). At the Big Bang, our universe was point-like. In 1931, Lemaître explained that the universe began with an "atom-primitive" with a radius that expends radially (Kragh H., 2012). Later, his vision was ironically surnamed by Hoyle "Big Bang" during a 1949 BBC broadcast (Kragh H., 2013). At the Big Bang, the friction was at its maximum. Once light appeared ~360 000 years after the Big Bang, a vast expanding sphere made of light appeared surrounding the initial mass. We named it ″luminous universe″ (Mercier C., 2019a). Hubble was the first to observe the universe's expansion (Hubble E., 1929). Since Einstein, with the laws of relativity (Einstein A., 1905), showed that matter cannot travel through space as fast as light, matter necessarily accumulates a delay. Therefore, it creates a second sphere nested in the first one, with the same source of expansion corresponding to the center of mass of the universe (Mercier C., 2019a). The expansion limit of the material universe is at a proportion β of the luminous universe, which travels at the speed of light c (Mercier C., 2019a). Therefore, β represents the speed ratio between the material and the luminous universe (the speed of light c).

Based on special relativity, Einstein showed that the presence of a mass m modifies the proprieties of space-time and reduces the speed of light (Einstein A., 1911). A photon located at a distance r from the center of mass m would then have a speed v_L. Based on general relativity equations (Einstein A., 1916), in a weak gravitational field context (when the gravitational potential $\Phi \ll c^2$), Schwarzschild gave the following solution (Grøn Ø., 2016) (Binney J. and Merrifield M., 1998).

$$v_L(r) = \frac{c}{n_0} \quad \text{where} \quad n_0 = \sqrt{\frac{1-2\Phi/c^2}{1+2\Phi/c^2}} \quad \text{and} \quad \Phi = \frac{-Gm}{r} \le 0 \tag{1}$$

In 2019, based on Equation (1), we hypothesized that the universe's expansion also modifies the proprieties of space-time by reducing the space density (Mercier C., 2019a). As the universe expands, its mass goes away from the center of mass of the universe. It then allows a slight acceleration of light a_L over time. Even if c is the actual speed limit, the speed of light will tend towards a new value baptized k when the apparent radius R_u of curvature of the universe will tend towards infinity. The consequence of this is that the speed c will no more be the speed limit in the future. We kept the spirit of Equation (1), but we replaced the speed limit by k. Then we modified the gravitational potential by Θ so that v_L becomes equal to the actual speed of light c for a radius r_u corresponding to our exact emplacement in the universe.

$$v_L(r_u) = \frac{k}{n} = c \quad \text{where} \quad n = \sqrt{\frac{1-2\Theta/k^2}{1+2\Theta/k^2}} \quad \text{and} \quad \Theta = \frac{-Gm_u}{r_u} \le 0 \tag{2}$$

The luminous universe's apparent radius R_u of curvature (sometimes called ″Hubble radius″ as by Zichichi A., 2000) can be calculated by assuming a continuous speed of light c during a time equal to the apparent age of the universe. This age is $1/H_0$ (Mercier C., 2019a and 2021) (where H_0 is Hubble constant which we evaluated to about 72.09 km·s^{-1}·MParsec^{-1}). In 2019, we showed different ways to calculate R_u (Mercier C., 2019a and 2019b). We may simply call it the universe's radius to make it shorter in the text.

$$R_u = \frac{c}{H_0} \approx 1.28 \times 10^{26}\,\text{m} \tag{3}$$

Our material universe parcel is a fraction β of the total luminous universe radius R_u. Therefore, we get:

$$r_u = \beta R_u \approx 0.97 \times 10^{26}\ \text{m} \tag{4}$$

If the expansion speed of the material universe is v_m, it is a fraction β of the expansion speed v_L of the luminous universe. The derivative of the v_m speed evaluated to our emplacement r_u is Hubble constant H_0.

$$\left.\frac{dv_m}{dr}\right|_{r=r_u} = \beta \left.\frac{dv_L}{dr}\right|_{r=r_u} = H_0 \tag{5}$$

In 1995, Carvalho J. C. calculated the apparent mass m_u of the universe. We also found the same result in 2019 (Mercier C., 2019a and 2019b).

$$m_u = \frac{c^3}{GH_0} = \frac{c^2 R_u}{G} \approx 1.73 \times 10^{53}\,\text{kg} \tag{6}$$

From a system of 5 equations (made of Equations (2), (3), (4), (5), and (6)), we deduced the 5 unknowns β, k, r_u, R_u, and m_u (Mercier C., 2019a). The β constant is unique to our model, but it turns out to be essential for building several equations linking different parameters of the universe (Mercier C., 2019a).

$$\beta = 3 - \sqrt{5} \tag{7}$$

In our model, while the universe expands, all universe's mass elements move away from the center of mass of the universe. As a result, the universe becomes less dense and reduces its influence on light, which allows the speed of light to increase very slowly.

At our location in the universe, i.e., at $r = r_u$, the light's acceleration a_L is given by Equation (8).

$$a_L\big|_{r=r_u} = \left.\left(c\frac{dv_L}{dr}\right)\right|_{r=r_u} = \frac{cH_0}{\beta} \approx 9.17 \times 10^{-10}\,\text{m}\cdot\text{s}^{-2} \tag{8}$$

At the periphery of the universe, i.e., at $r = R_u$, the light's acceleration a_L is given by Equation (9).

$$a_L\big|_{r=R_u} = \left(c\frac{dv_L}{dr} \right)\Bigg|_{r=R_u} = cH_0 \approx 7.00\times10^{-10}\,\mathrm{m\cdot s^{-2}} \tag{9}$$

The light speed rate of variation is so small that it passes entirely unnoticed for the moment. For example, here at our location, it will take about 35.6 years before the speed of light changes by 1 m/s. However, at the edge of the luminous universe, the light speed increases by about 1 m/s every 45.3 years. Of course, there is a β factor between these two values due to Equation (5). In our model, the speed of light remains and will stay an unsurpassable speed limit, whatever this parameter becomes in the future.

The International Bureau of Weights and Measures (In french: Bureau International des Poids et Mesures, BIPM) stated in 1983 that the speed of light in a vacuum c is constant and became a standard (Bernard J. and Blanc-Lapierre A., 1983). We want to mention that the decision of the BIPM was a choice to facilitate the establishment of a standard. The impacts are enormous. For example, even if the speed of light increases over time, we force it to remain constant. Therefore, in this situation, we unconsciously and continuously redefine the basic units (the meter, the second, and the kilogram), which impacts all the physics parameters. The good side of this choice is that most unit-dependant (probably all) parameters of the universe stay ″constant″. However, it complexifies a few phenomena that could be explained much more easily if we could accept the concept of a non-constant speed of light. For example, imposing the speed of light c to be constant forces the fine-structure α parameter to change imperceptibly and slowly over time (Prestage John D., Tjoelker Robert L., and Maleki Lute, 1995) (Fortier T. M. et al., 2007) (Murphy M. T. et al., 2001) (Cingöz A. et al., 2007) when it should not. Indeed, the fine-structure constant α is a ratio made of two parameters of the same units. For example, it can depict the ratio between the classical radius r_e of an electron and the Compton radius r_c of an electron. It can also be the ratio between the square value of an elementary charge q_e and $4\pi\varepsilon_0\hbar c$. Many other ratios can describe the fine-structure constant α. As the fine-structure constant is unitless, the numerator unit is the same as its denominator. It also means that if a change occurs to the numerator over time, the same modification in percentage will appear on the denominator. Therefore, α is indeed a constant. It implies that we should admit that the changes attributed to the fine-structure constant should instead be on the speed of light and all other unit-dependant parameters of the universe.

Nevertheless, stating that the speed of light remains constant is a good choice from a metrology point of view. It suffices to be aware of this choice and mention it in our works to ensure that the reader will not misinterpret our thinking processes. So, in this work, and all other previous ones (Mercier C., 2019a, 2019b, 2020, and 2021), we choose to keep the fine-structure α really constant, and we accept that all other parameter-dependent physics ″constants″ change slowly over time.

In 2019 (Mercier C., 2019a), using the large numbers from the Dirac hypothesis (Dirac P. A. M., 1938 and 1974), we showed that all these large numbers might be described from only one we called N using different rational exponents. This number represents the maximum number of photons of the lowest energy contained in the universe. We can find its value by dividing the apparent mass m_u of the universe (see Equation (6)) by the mass m_{ph} of a photon associated with the largest wavelength that can be contained in the universe, i.e., the circumference of the universe ($2\pi R_u$). We also found that N is linked to the fine-structure constant α.

$$N = \frac{m_u}{m_{ph}} = \frac{1}{\alpha^{57}} \approx 6.303419702(84)\times10^{121} \tag{10}$$

The mass m_{ph} may be found by equating mass energy to wavelength energy.

$$m_{ph}c^2 = \frac{hc}{2\pi R_u} \quad \rightarrow \quad m_{ph} = \frac{h}{2\pi R_u c} \approx 2.74\times10^{-69}\,\mathrm{kg} \tag{11}$$

In 2019 (Mercier C., 2019a), we found that we could find the universal gravitational constant G and describe it as a function of the electron characteristics using Equation (10) with the previous equations found from our Cosmological model.

In 2019 (Mercier C., 2019a), we found that using Equation (10) with the previous equations found from our Cosmological model could lead to the universal gravitational constant G by describing it as a function of the electron characteristics.

$$G = \frac{c^2 r_e \alpha^{20}}{m_e \beta} \approx 6.673229809(86)\times10^{-11}\ \mathrm{m^3\cdot kg^{-1}\cdot s^{-2}} \tag{12}$$

Equation (12) gives a result that is the best fit over 35 measured values (using a cubic-spline) (Mercier C., 2020). It is also in agreement with the value of $G \approx 6.6732(31)\times10^{-11}$ $m^3 \cdot kg^{-1} \cdot s^{-2}$ (Taylor B. N., Parker W. H., and Langenberg D. N., 1969). Furthermore, it is close to the CODATA 2014 value within 130 ppm (part per million). Therefore, we will use Equation (12) and its value throughout the rest of the article.

In 2019 (Mercier C., 2019), from the same model, we also showed that Hubble constant H_0 might be described theoretically as a function of the electron characteristics.

$$H_0 = \frac{c\alpha^{19}\sqrt{\beta}}{r_e} \approx 72.09548580(32)\ \mathrm{km}\cdot\mathrm{s}^{-1}\cdot\mathrm{MParsec}^{-1} \tag{13}$$

Equation (13) represents the best fit over 608 measured values (Mercier C, 2021). Our result is similar to 72.1 ± 2.0 $km \cdot s^{-1} \cdot MParsec^{-1}$ (Soltis J., Casertano S., and Riess A. G., 2021), $72.1^{+2.1}_{;-1.8}$ $km \cdot s^{-1} \cdot MParsec^{-1}$ (Martinelli M. and Tutusaus I., 2019), and $72.1^{+3.2}_{;-2.3}$ $km \cdot s^{-1} \cdot MParsec^{-1}$ (Salvatelli V, Marchini A, Lopez-Honorez L, and Mena O., 2013). Therefore, we will use Equation (13) throughout the rest of the present article.

In 2019, we showed that we could calculate the average CMB (Cosmological Microwave Background) temperature theoretically with the following equation (Mercier C., 2019a):

$$T = \frac{m_e c^2}{k_b}\left(\frac{15\beta^6\alpha^{17}}{\pi^3}\right)^{1/4} \approx 2.7367958(16)\ °\mathrm{K} \tag{14}$$

Equation (14) is in agreement with the results of the Cobra probe (Gush H. P., 1981) with $T \approx 2.736(17)$ °K and with Partridge (Partridge R. B., 1997), who obtained $T \approx 2.734(10)$ °K. Let us mention that we got this equation by hypothesizing that the universe is spinning on itself at a relativistic tangential speed close to the speed of light. We will see further that this tangential rotation speed is the same as an electron. Without this assumption, a static universe would have a temperature of $T \approx 32$ °K. However, it would be false considering the measurements of Gush H. P., Partridge R. B., and Fixsen D. J., 2009. Therefore, the universe must rotate on itself.

3. Method

To calculate the moment of the occurrence of light, we must start by considering the relativistic Einstein's spinning disk effects. Then, to evaluate the relativistic effects, we must determine the rotating tangential speed of the universe.

3.1 Einstein's Spinning Disk Effects Applied to Our Universe

Let us suppose a rigid mass-less disk at rest. Its circumference is $2\pi r$, where r is the disk radius. This equation is valid if the disk stays at rest. Let us glue two rigid 1-meter rods, one on the radius r and one on the circle's periphery (tangential to the radius). The two rods have the same length for an observer at rest and a disk at rest.

Like Einstein did in 1912, let us consider another situation where the disk spins with a tangential relativistic speed v. The first observation is that the maximum tangential speed v cannot be faster than light in a vacuum c. The larger the disk is, the lower is the angular speed ω. We might want to estimate the disk circumference using the standard $2\pi r$ equation. However, this would be a big mistake for a rotating disk, especially with relativistic tangential speeds. An observer at rest would note that the two rods have no longer the same length. The rod stuck on the radius remains 1-meter long, but the rod stuck on the disk periphery seems smaller because of the special relativity effects. As the peripheral rod looks smaller than a disk at rest, we can stick more similar rods on the periphery, and the circumference length seems greater than $2\pi r$. For an observer at rest, the circumference now looks like being L_c.

$$L_c = \frac{2\pi r}{\sqrt{1-\frac{v^2}{c^2}}} \tag{15}$$

The radius looks like becoming artificially larger for an observer at rest because of the relativistic effects. Therefore, because of the relativistic effects, the radius now looks like being r':

$$r' = \frac{r}{\sqrt{1-\frac{v^2}{c^2}}} \tag{16}$$

Let us build a particular sphere made of disks stacked on a shaft. Each disk has no friction with its neighbors, and each disk periphery has the same tangential speed *v*. Each disk is infinitely thin. Therefore, the rotating volume *V* of the sphere becomes the integral of all stacked disks.

$$V = \frac{4}{3}\pi\left(\frac{r}{\sqrt{1-\frac{v^2}{c^2}}}\right)^3 \tag{17}$$

One may question why stacked disks have the same tangential speed *v* regardless of their radius. We made this choice to fit what we think is the reality of our universe. We assumed rigid disks, but this scenario was used to easily visualize what happens when we apply a torque on a shaft to force a disk to spin. However, in our universe, there is no rigid disk. Although, there is friction, and there is conservation of movement.

3.2 Determination of the Rotating Tangential Speed v of the Universe

Each disk element periphery of the luminous universe rotates with a tangential speed *v*. This speed is very close to *c* since the luminous universe is built with light. We need to know its precise value to adequately evaluate the relativistic effects of the universe rotation. We will then test our hypotheses by calculating the average temperature of the CMB. Comparing the result of our calculation to the measured value of the CMB, we will determine if our hypothesis makes sense or not.

One could object that our universe may be not spin on itself. However, others than us think that the universe turns on itself. Other scientists (Hawking S., 1969 and Fennelly A. J., 1976) have already made the hypothesis of a rotating universe. Nevertheless, we must find evidence to support this hypothesis.

Let us suppose a mass-less rigid rod with an infinity length. If it does not rotate, it is theoretically possible to keep the rod straight. However, even if it turns very slightly, and even if it is infinitely rigid, there will be somewhere on the rod where the tangential speed will be the speed of light. As it is impossible to move faster than light, the rod will start to curve on itself by relativistic effects. The length of the rod and its radius will then depend on the angular speed of rotation. It is the same for the universe. Its angular rotation speed is extremely slow, and the apparent radius of curvature of the universe is currently $R_u \approx 1.28\times10^{26}$ m. At the other extreme, if the angular is at its maximum, the radius will become equal to Planck length. If we apply Equation (17) to the universe, the radius *r* will become R_u which is the apparent radius of the universe. However, at this point of the discussion, we still do not know the value of *v*. We need to know its value to go further.

Let us hypothesize that the tangential speed of the universe's periphery is the same as an electron.

When the universe began to expand after the Big Bang, the light was not existing. For a photon emission, an electron must pass from an orbital corresponding to a high energy level to another orbital corresponding to a lower energy level, approaching the nucleus. At its beginning, the universe was made of such a compact matter that electrons could not move. Therefore, the universe was dark, with no light.

Once the density of matter reduced enough to give some freedom around the nucleus, electrons began to emit light, and the universe became transparent. This event happened ~360 000 years after the Big Bang. Just before this moment, the universe was spinning with a certain tangential speed *v*. The friction and the tangential speed of the universe were so intense that whatever was on its surface (i.e., electrons) was forced to roll with the same tangential speed as the universe. We claim that the universe rotation may have initiated the electron's spin. It would explain why all electrons have the same spin and charge. Llewellyn assumed that the electron spin is caused by a rotation of the electron on itself (Llewellyn T., 1926). We think the same thing. When the universe began its existence, its total quantity of movement was necessarily null (for translation and rotation movements). Then, as soon as the universe was just a big hard block and there were enough spaces between the particles, the universe could spin since the particles could roll in the opposite direction to the universe to maintain a zero angular momentum.

When the universe began to radiate light radially to the surface of the universe, it created the ″luminous universe″. Therefore, we think that the radius of the luminous universe started to increase radially from the surface of the universe sphere at the speed of light and is still expanding at light speed. However, let us note that, at that time, the speed of light was slower than now. According to our calculations, it still increases over time toward an asymptotic value k (which is about $2c$ (Mercier C., 2019a)). The k value will be reached when the apparent radius of curvature of the universe tends towards infinity.

The universe's radius value for which the tangential speed is v is a bit smaller than R_u corresponds to a universe's radius that started to increase at the speed of light from the Big Bang. This delay is caused by the light appearing ~360 000 years after the Big Bang. Even if the speed of light slowly increased over time, we can talk about an apparent universe age that would be about $1/H_0$ (Mercier C., 2019a and 2021). Effectively, we surname that age of the universe as being ″apparent″ because it is the age that we would obtain by assuming a constant speed of light equal to the actual value c. If we took a picture of now without knowing how the past was and how the future will be, we would obtain that value using the assumption that the universe continuously expanded with a constant speed of light c. The universe's age is not just of real type. It is of complex type, with a real and an imaginary part. The apparent age associated with this complex age is the hypothenuse of a right triangle.

Because of the delay of ~360 000 years, the tangential speed of the periphery of the luminous universe is not entirely the speed of light but a bit less. Indeed, it is about the following fractional ratio of the light speed c:

$$\text{Tangential speed of the universe } \approx \left(\frac{\text{13.56 billion years - 360 000 years}}{\text{13.56 billion years}}\right)c \approx 0.999973c \tag{18}$$

If we now look at an electron, its classical radius is r_e. This value is the radius for which the electron sphere contains its entire mass due to its electrical charge. As for the universe, the electrons themselves are mini-worlds expanding at the same rhythm as the rest of the universe. So, the radius for which the electron would have a tangential speed of light c is slightly larger than the classical radius r_e. Nevertheless, the proportions will be the same as for the universe. The increasing size of an electron versus the expanding size of the universe is like tiny bubbles in a spherical sponge from which we release the pressure of our hand. The multiple tiny bubbles inside the sponge increase in size at the same rhythm as the whole. We try to say that everything increases in dimensions at the same rhythm as the entire universe. Nothing escapes to this law, not even Planck length L_p.

Suppose we continue to claim that the tangential speed of the electron (at its classical radius r_e) is the same as the tangential speed of the universe. It means that the tangential velocity of the electron is about $v \approx 0.999973c$. Since such a speed is relativistic, we must use Einstein's spinning disk principles. Therefore, we can apply Equation (16). For an observer at rest, the circumference of the electron sphere will not look like being $2\pi r_e$ anymore. It will rather look much more significant (the size of Compton radius r_c) because of the relativistic effects explained by Einstein's spinning disk effects. It is like increasing the classical radius r_e of the electron with a magnifying lens because of relativistic effects. We now get Equation (19).

$$r_c = \frac{r_e}{\sqrt{1-\frac{v^2}{c^2}}} \tag{19}$$

By definition, Compton radius is given as a function of the fine-structure constant α.

$$r_c = \frac{r_e}{\alpha} \tag{20}$$

We obtain the following identity from Equations (19) and (20). We compare the fine-structure constant α to the Lorentz factor in a relativistic equation:

$$\alpha = \sqrt{1-\frac{v^2}{c^2}} \quad \Rightarrow \quad v = c\sqrt{(1+\alpha)(1-\alpha)} \approx 0.999973c \tag{21}$$

Since the values of v from Equations (18) and (21) are the same, we conclude that our hypothesis may be true.

3.3 Einstein's Spinning Disk Effects Applied to Our Universe

We want to use an experiment to confirm our hypothesis that the tangential speed of the universe is the same as for an electron. With Einstein's spinning disk effects, we can calculate the average temperature T of the CMB theoretically. If our hypothesis is true, our calculation result will make sense and should be around what is measured by the Cobra probe with $T \approx 2.736(17)$ °K. On the other hand, if our hypothesis is false, the result will be anything else. The following calculation process of the CMB temperature was already shown in the past (Mercier C., 2019a). However, we will reiterate our main steps since it is essential for the actual demarche.

The universe is like a black body (Alpher R. A. and Herman R. C., 1948). It absorbs all electromagnetic energy. The thermal agitation due to the absorption causes the emission of thermal radiation. The surface of the luminous universe sphere emits a radiation spectrum as a function of its average temperature. The density flux M^o (in W·m^{-2}) of that radiation may be determined by the Stefan-Boltzmann law as a function of the surface temperature T (in °K).

$$M^\circ(T) = \sigma T^4 \tag{22}$$

Stefan-Boltzmann's constant σ is given by Equation (23).

$$\sigma = \frac{2\pi^5 k_b^4}{15h^3c^2} \approx 5.67\times10^{-8}\ \mathrm{W\cdot m^{-2}\cdot{}^\circ K^{-4}} \tag{23}$$

The whole power P_u dissipated in the universe creates a flux density on the surface of the luminous universe that is dissipated over the entire area A_u of the sphere. Therefore, we can calculate the power P_u by spreading the total energy E_u of the universe over a time equivalent to its apparent age of $T_u = 1/H_0 \approx$13.56 billion years.

$$M^\circ = \frac{P_u}{A_u} = \frac{E_u}{A_u T_u} = \frac{E_u H_0}{A_u} \tag{24}$$

With special relativity (Einstein A., 1905), Einstein showed that a mass m in movement might transform itself into pure energy E_t.

$$E_t = mc^2 \tag{25}$$

The apparent universe mass m_u from Equation (6) represents the total energy of our expanding universe. So, we can replace m from Equation (25) with the apparent mass of the universe m_u. Therefore, we may also replace the energy E_t from Equation (25) with the total energy E_u contained in the universe.

$$E_u = m_u c^2 = \frac{c^5}{GH_0} \tag{26}$$

We then calculate the average CMB temperature T by using Equations (6), (22), (23), (24), and (26).

$$T = \frac{1}{k_b}\left(\frac{15h^3c^7}{2\pi^5 A_u G}\right)^{1/4} \tag{27}$$

The statistical entropy S was expressed in 1877 by Boltzmann (see Boltzmann L., 1974) as a Ω function representing the microstates of a given macroscopic system at the equilibrium.

$$S = k_b \ln(\Omega) \tag{28}$$

The material universe expands β times slower than the luminous universe (Mercier C., 2019a). Entropy is someway a measure of the disorder in the universe. The disorder and the entropy increase while the universe expands. The measurement of the entropy S' at R_u is given by Equation (29).

$$S' = \frac{S}{\beta} = \frac{k_b \ln(\Omega)}{\beta} = k_b' \ln(\Omega) \quad \text{where} \quad k_b' = \frac{k_b}{\beta} \tag{29}$$

The "Boltzmann constant" k_b is not constant through the universe. It is valid only locally, at our position r_u, relative to the center of mass of the universe. Equation (27) becomes Equation (30) when an observer at rest looks at the periphery of the luminous universe. At the edge of the luminous universe (i.e., at $R_u = r_u/\beta$), the Boltzmann parameter k_b becomes $k'_{;b}$ as given in Equation (29).

$$T = \frac{1}{k_b'}\left(\frac{15h^3c^7}{2\pi^5 A_u G}\right)^{1/4} = \frac{\beta}{k_b}\left(\frac{15h^3c^7}{2\pi^5 A_u G}\right)^{1/4} \tag{30}$$

For a static universe (which is wrong), the area A_u of the luminous universe sphere surface is Equation (31).

$$A_u = 4\pi R_u^2 \quad \text{(Static universe)} \tag{31}$$

Assuming a static universe (which is wrong) by using Equation (31) in Equation (30) leads to an average CMB temperature of $T \approx 32$ °K (which is also false). As the Cobra probe measured $T \approx 2.736\,(17)$ °K, it becomes evident that the universe cannot be static. In a static universe, the volume is much smaller than in a rotating universe. It is too small to allow enough energy dissipation to obtain anything around 2.73 °K.

According to Einstein, because of relativistic effects shown in Equation (16), a rotating disk seems to have a larger circumference than a static disk (Einstein A., 1912).

As we mentioned earlier, we hypothesize that the universe rotates on itself. Other scientists (Hawking S., 1969 and Fennelly A. J., 1976) made the same assumption.

One could object that an observer needs a reference at rest around him to know whether he rotates or not. We could consider the universe is in this situation since we cannot see any reference outside the universe. We believe this objection completely wrong. The observer can always use himself as a reference. For example, let us take a skater who spins on himself. Even if he closes his eyes to cancel any sense of reference, the simple fact that he turns on himself will make him feel the effect of the centrifuge force (which is a false force that can be explained by the fact that each particle of the body tries to go in a straight line).

As mentioned earlier, we also hypothesize that the tangential speed of rotation of the universe for a radius R_u is the same as the tangential speed of the electron's spin for its classical radius r_e, which implies that the Lorentz factor may be replaced by the fine-structure constant α. If we apply Equations (16) and (21) to the apparent radius R_u of curvature of the universe, an observer at rest who looks at the circumference that becomes greater because of relativistic effect would conclude that the radius of our universe is $R'_{;u}$.

$$R'_u = R_u/\alpha \quad \text{(Universe in rotation)} \tag{32}$$

Equation (33) is then used to evaluate the area A_u of the outer surface of the sphere of our universe from Equations (31) and (32).

$$A_u = 4\pi R_u^2/\alpha^2 \quad \text{(Universe in rotation)} \tag{33}$$

With Equations (3), (32), and (33), we modify Equation (30) to get Equation (34).

$$T = \frac{\beta}{k_b}\left(\frac{15\alpha^2 h^3 c^5 H_0^2}{8\pi^6 G}\right)^{1/4} = \frac{\beta}{k_b}\left(\frac{15 m_e \beta^2 h^3 c^5 \alpha^{20}}{8\pi^6 r_e^2}\right)^{1/4} \approx 2.7367958(16)\ \text{°K} \tag{34}$$

This temperature is what has been measured by the Cobra probe with 2.736(17) °K. Therefore, it confirms our hypothesis that the tangential speed of the universe is the same as for an electron.

3.4 Calculation of the Moment of the Occurrence of Light

We will calculate the moment when the first photons appeared in the universe.

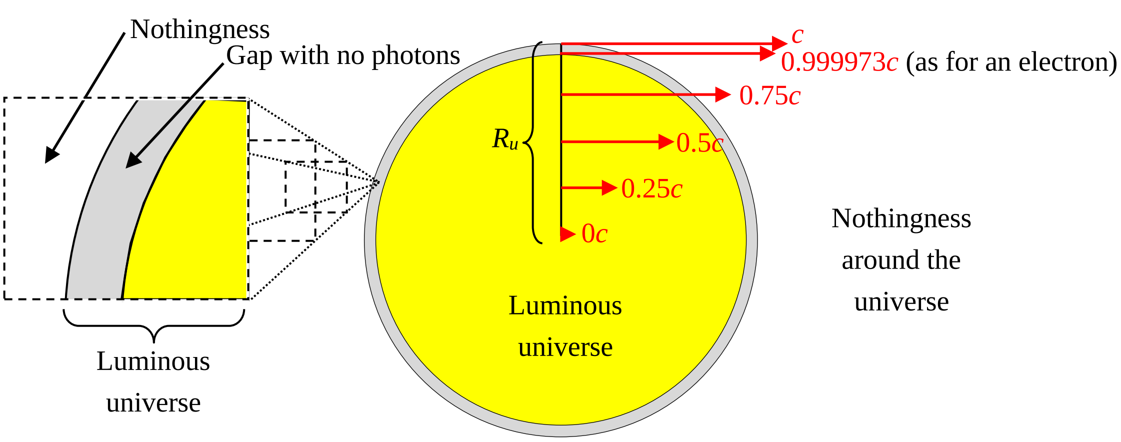

Figure 1. Tangential speed vector (in red) increasing from 0 to c as a function of radius

If we suppose that the universe has begun to emit photons from the Big Bang (which is not the case), the luminous universe would have a radius equal to R_u. However, we know that this can not be the case. Indeed, when the Big Bang occurred, the universe's density was too high to allow the formation of atoms. Therefore, for the first photons to be emitted, it was necessary to wait for the universe to undergo a minimum of expansion, cool a little, and leave enough free space between the particles to form atoms with their nucleus composed of neutrons and protons with electrons on orbitals. Electrons could then emit the first photons by changing orbitals.

This delay in the formation of photons means that the luminous universe has a radius slightly less than R_u, which also means that the luminous universe can not be in rotation with a tangential speed equal to c but rather with a slightly lower tangential velocity.

However, the radial expansion (parallel to the radius) of the luminous universe occurs at a speed of light c.

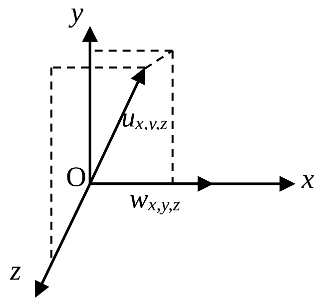

Figure 2. When we add two velocity vectors, it is always possible to choose a coordinate system to align the vector w_{xyz} on the x-axis. Then, the u_{xyz} vector can point anywhere else.

First, let us show how to make a relativistic summation of two velocity vectors $u_{x,y,z}$ and $w_{x,y,z}$. To simplify the problem, we choose a reference frame to express the velocity vector $w_{x,y,z}$ so that $w_y = 0$ and $w_z = 0$. We must make the rotations and translations required to superimpose the vector $w_{x,y,z}$ with the x-axis. However, it is always possible to do so.

The following three equations result in the vector $v_{x,y,z}$.

$$v_x = \frac{u_x + w_x}{1 + \frac{u_x \cdot w_x}{c^2}} \qquad v_y = \frac{u_y \sqrt{1 - \left(\frac{w_x}{c}\right)^2}}{1 + \frac{u_x \cdot w_x}{c^2}} \qquad v_z = \frac{u_z \sqrt{1 - \left(\frac{w_x}{c}\right)^2}}{1 + \frac{u_x \cdot w_x}{c^2}} \tag{35}$$

Let us suppose now that we simultaneously analyze the expansion and rotation of the universe locally. Let us consider the case where the luminous universe radius expands at the velocity of light c on the y-axis with $u_x = 0$, $u_y = c$, and $u_z = 0$. Let us also suppose that, arbitrarily, the universe is also rotating on the x-axis with a tangential velocity w_x with $w_y = 0$ and $w_z = 0$ (as explained above).

Let us apply this new data to Equations (35). The equations simplify to obtain:

$$v_x = w_x \qquad v_y = \sqrt{c^2 - w_x^2} \qquad v_z = 0 \tag{36}$$

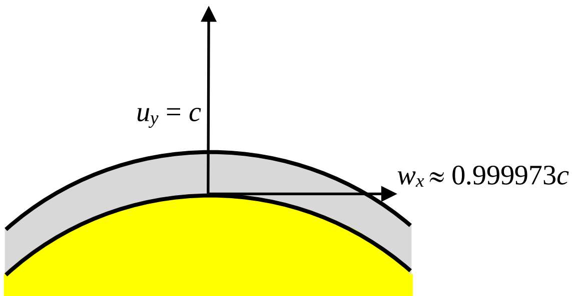

Figure 3. The apparent universe's radius R_u of curvature increases at the speed of light $u_y = c$, and the universe's tangential rotation speed is w_x.

If we calculate the module $\left|v_{x,y,z}\right|$ of the resulting vector AB, we obtain:

$$\left|v_{x,y,z}\right| = \sqrt{v_x^2 + v_y^2 + v_z^2} = c \tag{37}$$

We note that a relativistic summation of two velocity vectors, one of which is arbitrary and the other is the speed of light, gives a resulting velocity vector that moves at the speed of light c (for now) with a direction influenced by the slowest speed vector. We must keep in mind that the speed of light v_L increases over time and will tend towards k in the very far future (when $R_u \to \infty$). The universe's expansion reduces its density and its refraction index n (see Equation (2)).

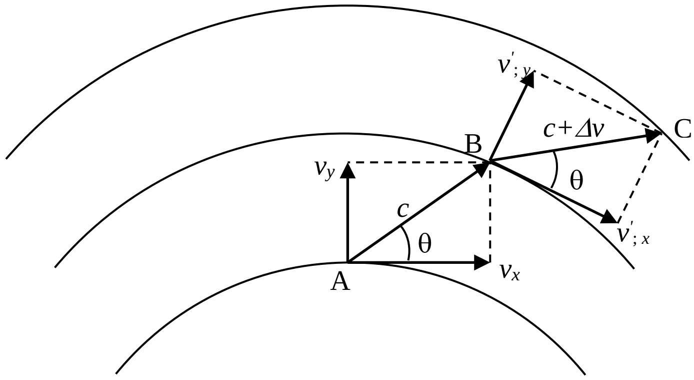

Figure 4. As the radius R_u of the universe increases at the speed of light, the light accelerates, and the light beam bends because of the universe's rotation

The actual expansion speed of the sphere of the universe is at the speed of light c. Since the sphere is also rotating at the speed v_x, point A will move to point B after a time equal to Planck's time t_p. The light will accelerate a little at each additional Planck time variation and increase with a value Δv. The same process will continue up to point C, and so on.

With the help of Equation (9) (because we are at the periphery of the luminous universe), let us evaluate the value of Δv. Planck time is $t_p \approx 5.39 \times 10^{-44}$ s represents a quantum of time.

$$\Delta v = a_L t_p = cH_0 t_p \approx 3.78 \times 10^{-53}\,\mathrm{m \cdot s^{-1}} \tag{38}$$

If we follow the progression over time and space of a given point located at the periphery of the luminous universe, we shall find that it will move by performing a growing spin. This spin will grow due to the angle θ.

Let us look to the sine of the angle θ. In Figure C, we find that:

$$c \cdot \sin\theta = v_y = \sqrt{c^2 - v_x^2} = c\sqrt{1 - \frac{v_x^2}{c^2}} \tag{39}$$

From Equation (39), we isolate sin θ:

$$\sin\theta = \sqrt{1 - \frac{v_x^2}{c^2}} \tag{40}$$

At the beginning of this article, we compared the universe to an electron that rotates on itself, and we have assumed that the fine structure constant α was precisely equal to the Lorentz factor for a tangential rotational velocity v_x:

$$\alpha = \sqrt{1 - \frac{v_x^2}{c^2}} \tag{41}$$

Using Equations (40) and (41), we find that:

$$\sin\theta = \alpha \tag{42}$$

By isolating the velocity v_x of Equation (41), we obtain:

$$v_X = c\sqrt{1-\alpha^2} \approx 0.999973c \tag{43}$$

Equation (43) means that the periphery of the luminous universe rotates with a tangential velocity very close to the speed of light without being precisely the speed of light.

We could also calculate this velocity by using the acceleration of light a_L at the periphery of the luminous universe. Indeed, the speed v_x is equal to the speed of light minus the acceleration it has undergone during a time Δt. Therefore, we must use Equation (9) to determine the a_L acceleration at the periphery of the luminous universe:

$$v_x = c - a_L \Delta t = c\left(1 - H_0 \Delta t\right) \tag{44}$$

Let us equate Equations (43) and (44) to obtain:

$$\sqrt{1-\alpha^2} = 1 - H_0 \Delta t \tag{45}$$

Let us isolate the time value Δt. Then, using Equation (13), let us determine Δt.

$$\Delta t = \frac{1-\sqrt{1-\alpha^2}}{H_0} = r_e\left(\frac{1-\sqrt{1-\alpha^2}}{c\alpha^{19}\beta^{1/2}}\right) \approx \text{ 361 108 years} \tag{46}$$

This equation means that if we go back to the past, at the beginning of the universe's expansion, it took about 361 108 years (of our present time) for the first photons of light to be emitted. Our result is approximately equal to the ~360 000 years (Jenkins A., Villard R., and Riess A. 2018) and the ~380 000 years (Turner M. S., 2009).

The universe's apparent age $T_u = 1/H_0$. Using Figure 1, we note that the tangential speed of the luminous universe is a fraction $(T_u$-$\Delta t)/T_u$ of the speed of light c (as we did in Equation (18)). Then, if we force this corresponding speed to equal the tangential speed of an electron, we get Equation (47).

$$c\left(\frac{T_u - \Delta t}{T_u}\right) = c\left(\frac{\frac{1}{H_0} - \Delta t}{\frac{1}{H_0}}\right) = c\sqrt{1-\alpha^2} \approx 0.999973c \tag{47}$$

If we isolate Δt from Equation (47), we get the same result as Equation (46). Using Equation (13), we can find a good approximation of Equation (46) with the following equation:

$$\Delta t = \frac{1-\sqrt{1-\alpha^2}}{H_0} \approx \frac{1-\left(1-\frac{\alpha^2}{2}\right)}{H_0} \approx \frac{\alpha^2}{2H_0} \approx 361103 \text{ years} \tag{48}$$

Nowadays, we know that the universe is expanding and that this expansion is the leading cause of light acceleration over time. The calculation of the luminous universe's apparent radius gives R_u. However, this value provides the universe's apparent radius if the emission of photons had begun at the beginning of the Big Bang. For a radius R_u, the tangential velocity would be precisely the velocity of light c. Since there is a delay in the emission of photons, the apparent radius of the universe where there is a presence of photons is slightly smaller than R_u, and the tangential rotation speed is less than the velocity of light, i.e., about $0.999973 \cdot c$, that is the tangential speed of rotation of an electron.

Hypothetically, if there had been emission of photons from the Big Bang, the luminous universe would have been expanding at the speed of light c on the y-axis, i.e., $u_x = 0$, $u_y = c$, and $u_z = 0$. The universe would also have been rotating at the speed of light c on the x-axis with a tangential $u_x = c$, $u_y = 0$, and $u_z = 0$. We would then have found that the resulting velocity vector would have been:

$$v_x = c \qquad v_y = 0 \qquad v_z = 0 \tag{49}$$

Thus, without a nonzero fine-structure constant α, we would have a rotating universe that is not expanding, whatever value of the expansion rate u_y is used. However, if it had never been expanding, such a universe would have been of the smallest existing dimension (an apparent radius equal to Planck's length L_p). This result may seem highly bizarre, but it is a relativistic effect.

Over time, the variations in dimensions are infinitesimal because the particles spin on themselves with an angular speed so great that their apparent radius is of very small value. The speed of light, which serves as a standard, also increases over time. As a result, all wavelengths and dimensions (the meter, the second, and the kilogram) also change over time. Like the universe, particles spin with a tangential speed close to the light. However, in all proportions, the angle θ and the speed v_y of these particles are much smaller. It explains why the expansion of elementary particles over time occurs at a slower rate than for the universe. Indeed, the universe expands because in the infinitely small, all the universe constituents expand at a rate proportional to their relative size compared to the universe. It is a bit like when a sponge that has been crushed slowly relaxes. The total size of the sponge is directly related to the size of the bubbles that constitute it.

4. Results and Discussion

As Lemaître thought in 1931, in our universe model (Mercier C., 2019a), the universe has begun with a very dense point-like primitive atom that expends radially at the Big Bang. In the beginning, the universe was so dense that it was not possible to distinguish any particle or any photons. Everything seemed fused, and the universe was dark. However, after some time, the universe had expanded enough to allow the existence of the first atoms as we know them today. The electrons could change energy levels and emit the first photons from this moment. And there was light. According to our calculations, we found that light appeared ~361 108 years after the Big Bang. Even if this result is found using a different model than what cosmologists usually use, our result is about the same as ~360 000 years (Jenkins A., Villard R., and Riess A., 2018) and ~380 000 years (Turner M. S., 2009).

When the light appeared, the luminous universe began to expand at the speed of light. However, the speed of light was never constant throughout the universe's history. Einstein and Schwarzschild showed that the presence of a mass reduces the speed of light. As the universe expands, the universe moves away from its center of mass and decreases in density. Therefore, the universe's expansion allows a slight undetectable light acceleration over time. Here, at our location, it will take about 35.6 years before the speed of light changes by 1 m/s. However, at the edge of the luminous universe, the light speed increases by about 1 m/s every 45.3 years.

The luminous universe can be associated with a large sphere filled with photons of different wavelengths in our model. As matter cannot travel as fast as light, it created a second sphere (the material universe) imbricated in the first one. This model leads us to discover a new constant called $\beta \approx 0.76$, which represents the ratio between the expansion speed of the material universe versus the luminous universe.

Since 1983, the BIPM stated that the speed of light is constant for a metrology purpose. Even using lasers for its measurement, the variation in the light speed is undetectable. Therefore, claiming its constancy was looking logical. As we try to reference all main units to the speed of light, the impact of this choice is to force most universe's parameters to become constant. Nevertheless, even if this choice was excellent for a metrology purpose, it does not mean it correctly represents reality. Forcing the speed of light to be constant may increase the difficulty of explaining certain phenomena. As described in our document, the fine-structure parameter is really constant for good reasons. It is a ratio. Any change at its numerator will be the same at the denominator. Therefore, it will nullify. Because of the relativity of movement phenomenon, if we force the speed of light to be constant, the fine-structure parameter looks unconstant. We saw that the constancy of the fine-structure parameter depends on our choice about the constancy of the light celerity. Therefore, we have considered the speed of light being non-constant, which has the effect of making the fine-structure parameter appear constant.

When the universe was a compact sphere of matter, any rotating movement would give particles on its surface the same tangential rotation speed. Therefore, we hypothesized that the universe rotates on itself at a relativistic tangential speed that should be the same as the electron. According to Einstein's spinning disk theory, a disk at rest has a circumference of $2\pi r$ (where r is the radius), but when the disk spins at a relativistic tangential speed (which implies dividing the circumference by the Lorentz factor), the circumference increases. We associated that Lorentz factor with the fine-structure constant α. Then, we found that the tangential speed of the universe (and the electron) should be ~0.999973c. Considering that number, we calculated the temperature of the

Cosmological Microwave Background. To achieve it, we say that all the universe's mass is transformed into pure energy and dissipated in a volume equal to that of the universe. We made two tests: 1) with a static universe and 2) with a universe that rotates on the *x*-*y*-*z*-axis with a tangential speed of ~0.999973*c*. We found a temperature of ~32 °K for a static universe and ~2.7367958(16) °K for a rotating universe. As the Cobra probe measured a CMB temperature of 2.736(17) °K, we believe that our different assumptions make sense:

1) The luminous universe expands at the speed of light.

2) Our universe is spinning on itself.

3) The universe's periphery rotates with the same tangential speed as an electron.

4) Our model is made of a ″material universe″ imbricated in a ″luminous universe″. Therefore, it implies discovering the β constant used in many equations.

This article directly links the moment of the first emission of photons (and the universe's transparency) and the fine structure constant α. Indeed, we can consider that the first emission of photons is late compared to the beginning of the universe's expansion. This delay causes the universe (where there is a presence of photons) to have an apparent radius slightly smaller than R_u so that its tangential rotation speed is somewhat a bit less than that of light *c* (we found ~0.999973*c*).

In Equations (46) and (48), the reader will note that the moment of the appearance of the light is a function of the fine structure constant α and Hubble constant H_0. Knowing that the fine structure constant is really constant since it represents a ratio of two numbers having the same units, we conclude that the moment of the appearance of light varies according to the apparent age of the universe $1/H_0$. This statement might surprise many. However, the second is defined from the speed of light, and this latest accelerates over time (see Equations (8) and (9)). Therefore, the definition of elapsed time varies throughout the story. Furthermore, it is very counter-intuitive since our Cartesian mind is used to thinking that the notion of time does not change. However, it is easier to view this result as a "picture in time" of what this moment represents relative to the apparent age of the universe.

Finding precisely the moment of the occurrence of light helps to highlight a direct link with the fine-structure constant. Most physicists dream of finding a geometric equation describing exactly the fine-structure constant α. It is indeed as important as the speed of light *c* to describe many physics equations. However, apart from the fact that α represents a ratio of two numbers with the same units, physicists do not know much about it. Our article gives some other clues since we discovered that it might also represent the Lorentz factor in the electron spin. Furthermore, it may represent the sin θ relation in the rotation of the universe (see Equations (40) and (42)).

Since most particles are born simultaneously as light, we may find other links with the moment of occurrence of light in the future. This article has undoubtedly highlighted some new purposes of the fine-structure constant.

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