Calculation of the Average Temperature of the Cosmic Microwave Background and of Hubble Constant

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By making the assumptions that the universe is rotating [15] *and that it acts like a blackbody, it is possible to calculate the average temperature of the cosmic microwave background (CMB). Assuming a Hubble constant of $H_0 \approx 71.5 \pm 1.3$ km/(s·MParsec) as suggested by recent results of a research team that has combined different measurement techniques* [1], *we obtain a temperature of about 2.73 ± 0.03 ºKelvin.*[1] *This result is supported by a study of D. J. Fixsen* [6] *who made accurate measurements of the average temperature of the CMB to obtain $T \approx 2.72548 \pm 0.00057$ ºKelvin.*

Under similar conditions, we will see that a universe that is not in rotation would have had a temperature of about 31.9 ºKelvin, which is obviously not the case.

According to our calculations, we see that the measurement of T obtained in the D. J. Fixsen study has less uncertainty than H_0. Assuming that our theoretical equation is correct and equal to the value of T obtained by Fixsen, we can calculate a theoretical value for Hubble constant equal to $H_0 \approx 71.50 \pm 0.03$ km/(s·MParsec). This result is similar David Rapetti research team [1] *which obtained $H_0 \approx 71.5 \pm 1.3$ km/(s·MParsec). Moreover, our result is also consistent with the measurements of WMAP project from the NASA that obtained $H_0 \approx 70.4 \pm 1.4$ km/(s·MParsec)* [3].

According to our calculation and by the fact that the universe is in rotation, this implies that the average density of the universe is $\sigma_u \approx 7.4643 \pm 0.0002 \times 10^{-33}$ kg/m³.

KEY WORDS: Universe, rotation, temperature, cosmic microwave background, CMB, Hubble, density

1. INTRODUCTION

In nature, we can enumerate several examples of objects rotating around another (e.g., the electrons around the atomic nucleus, the Earth around the Sun, our solar system around the black hole of our galaxy, etc.). Therefore, we formulate the

[1] Recent works that we make allowed us to evaluate the Hubble constant to $H_0 \approx 72.09548632 \pm 0{,}000000046$ km/(s·MParsec) and the universal gravitational constant to $G \approx 6.67323036 \pm 0{,}00000030 \times 10^{-11}$ m³/(kg·s²). This situation allowed to revaluate the average temperature of the CMB to $T \approx 2.7367951 \pm 0.0000026$ °K [17].

hypothesis that the universe is in rotation. Many astrophysicists are considering the same assumption, such Stephen Hawking [15] and Fennelly [16]. We even think that it is rotating at a speed approaching the speed of light. This hypothesis leads us to use the concept of the rotating disk of Einstein. Indeed, the latter showed that the circumference of a rotating disk is greater than the one of a static disk [7]. Assuming that the circumference of the universe is divided by the rotation of the fine structure constant, we get a circumference that is approximately 137 times greater than if the universe was static. By equating the universe with a huge blackbody, we calculate what should be the average temperature of the cosmic microwave background (CMB). The result coincides perfectly with the temperature measurement made by observing the CMB.

We then make the observation that the measured temperature value of the CMB is known very accurately while the Hubble constant H_0 has a lot of uncertainty. This leads us to hypothesize that our equation is right and that it is precisely equal to the measured temperature of the background radiation of the universe. By doing the reverse road, we are able to isolate the value of the Hubble constant H_0 to calculate it theoretically based on the average temperature of the background radiation.

Finally, we will use our Hubble constant value to calculate the average density of the universe. This density will of course be affected by the fact that the universe is rotating.

2. DEVELOPPEMENT

2.1. Hypothesis on the Universe

Our universe may have one of two following states: being in rotation or not. The electrons rotate on themselves. They rotate around a nucleus. The Earth rotates around itself. It orbits around the Sun. Our sun rotates around the black hole which is located in the center of our galaxy. Examples of rotating systems are common in nature. In fact, very little can be considered static on long-term (if any). Examples of rotating systems are large enough to lead us to believe that there is more probability to see our universe in rotation than to see it being static.

Einstein thought the universe was finite and static [11]. However, even his equations of general relativity [14] led him to conclude that the universe was either expanding or contracting. It is his determination to think that it is static that led him to introduce the cosmological constant (mathematical trick that forces the equations of the universe to be static). However, Hubble showed in 1929, with its observations, that the universe was expanding [12]. Einstein then admitted that he made a mistake by inventing the cosmological constant. It would have been the first to make the prediction that the universe was expanding with a totally theoretical way.

If our universe is rotating, it has different impacts. First, it would have a preferred orientation. It could also have an electrical charge.

To have a rotating universe while not violating the principle of conservation of momentum, two possibilities open to us.

The first possibility is that there is a second universe that rotates in the opposite direction. This is a hypothesis which remains unverifiable because no one can probe or see outside of our universe. Our universe is like a jail from which no one can escape. In this state of things, our world would have an electrical charge opposite to that of the other universe.

The second possibility is the existence of something else inside of our universe that rotates in the opposite direction. The global momentum would be maintained and would be nil. That something else could very well be the area contained within the horizon. This hypothesis is more plausible since we already know that black holes are typically rotating at a speed approaching that of light. It is possible that this is the case of the horizon of our universe. In this version of our hypothesis, the overall charge of our universe would be zero. The charge contained in the black hole of the universe would be equal but opposite to the electrical charge contained in the rest of the universe. The universe is like a huge neutron with an electrical overall zero charge. Indeed, a neutron is mainly composed of one proton and one electron.

This second hypothesis seems more likely that the first one since it would explain why it is required that the speed of light is zero at the horizon of the universe [5]. Therefore, it is this assumption that we will discuss in this paper.

We believe that the hypothesis of a rotating universe implies an average temperature in the universe that should be around 2.72548 °K as mentioned in the Fixsen document [6]. The fact of finding an equation that would explain this average temperature on a theoretically way, based on our assumptions, would bring us comfort about the exactitude of these latest.

2.2. The Universe Seen as a Blackbody

The universe has all the properties of a blackbody. Indeed, as a blackbody, it does not reflect any light since the light is necessarily contained in the universe (assuming that there is no other universe or that our universe does not enter in collision with another hypothetical universe). Moreover, it radiates energy to the surface of the sphere of the universe according the theoretical curve of a blackbody. The emitted spectrum depends only on its temperature.

The Stefan-Boltzmann law allows finding the Mº flux density as a function of the temperature T (in Kelvin degrees) in W/m^2.

$$M^{\circ}(T) = \sigma \cdot T^4 \tag{1}$$

Here, σ constant is Stefan-Boltzmann constant. It is defined by:

$$\sigma = \frac{2 \cdot \pi^5 \cdot k_B^4}{15 \cdot h^3 \cdot c^2} \approx 5.67 \times 10^{-8} \frac{\mathrm{W}}{\mathrm{m}^2 .^{\circ}\mathrm{K}^4} \tag{2}$$

In this equation, $h \approx 6.62606957 \times 10^{-34}$ J·s is Planck constant [10], $c \approx 299792458$ m/s is the speed of light in vacuum [10] and $k_B \approx 1.3806488 \times 10^{-23}$ J/ºK is Boltzmann constant [10].

2.3. Calculation of the Average Temperature of the CMB

La densité de flux à la surface de la sphère représentant l'univers lumineux peut être définie comme étant la puissance totale dissipée dans l'univers P_u sur l'aire totale A_u de la sphère de l'univers lumineux. La puissance dissipée P_u correspond à prendre l'énergie totale E_u et à la diviser par l'âge apparent de l'univers T_u=1/H_0 où H_0 est la constante de Hubble.

The flux density on the surface of the sphere representing the luminous universe can be defined as the total power P_u dissipated in the universe through the total area A_u of the sphere of the luminous universe. The power P_u itself is the total energy of the universe E_u divided by the apparent age of the universe T_u =1/H_0 where H_0 is the Hubble constant:

$$M^{\circ} = \frac{P_u}{A_u} = \frac{E_u}{A_u \cdot T_u} = \frac{E_u \cdot H_0}{A_u} \tag{3}$$

Einstein has shown that the total energy of a body is given by the following equation [13]:

$$E_t = \frac{m_0 \cdot c^2}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{4}$$

According to Einstein, the mass of a body in motion is given by [13]:

$$m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{5}$$

Therefore, the total energy of a moving body is given by:

$$E_t = m \cdot c^2 \tag{6}$$

The apparent mass of the universe is given by the following equation [3,4]:

$$m_u = \frac{c^3}{G \cdot H_0} \approx 1.8 \times 10^{53} \text{kg} \tag{7}$$

In equation **(7)**, the universal gravitational constant is given by $G \approx 6.67384 \times 10^{-11}$ m^3/(kg·s^2) [10]. In terms of Hubble constant H_0, the most recent value obtained by the David Rapetti's research team [1] is around $H_0 \approx 71.5 \pm 1.3$ km/(s·MParsec). In this paper, we will use this value.

The mass of the universe m_u is already the one of the expanding universe. Therefore, $m_u = m$ in equation **(6)**. So, the universe E_u energy becomes:

$$E_u = m_u \cdot c^2 = \frac{c^5}{G \cdot H_0} \tag{8}$$

Using equations **(1)**, **(2)**, **(3)** and **(8)**, we get:

$$T = \left(\frac{15 \cdot h^3 \cdot c^7}{2 \cdot \pi^5 \cdot k_B^4 \cdot G \cdot A_u} \right)^{\frac{1}{4}} \tag{9}$$

Ludwig Boltzmann's statistical entropy expressed by the number of microstates Ω defining the equilibrium of a given system at the macroscopic level:

$$S = k_B \cdot \ln(\Omega) \quad \text{where} \quad k_B = 1.380658 \times 10^{-23} \text{ J/°K [10]} \tag{10}$$

We have shown that the expansion velocity of the material universe is β times slower than the expansion of the luminous universe [5]. The value of β is a pure number.

$$\beta = 3 - \sqrt{5} \approx 0.76 \tag{11}$$

Since the entropy of the universe is somehow a measure of disorder in the universe, it should suggest that the entropy increases at the same rate as the expansion of the universe. The entropy measured at the edge of the luminous universe as light would have the value of *S*':

$$S' = \frac{S}{\beta} = \frac{k_B \cdot \ln(\Omega)}{\beta} = k'_B \cdot \ln(\Omega) \quad \text{where} \quad k'_B = \frac{k_B}{\beta} \tag{12}$$

The « Boltzmann constant » would be true only locally in our universe, at our r_u position with respect to the centre of the sphere which defines the universe. However, at the extreme limits of the luminous universe, at the $R_u = r_u/\beta$ position, « Boltzmann constant » would rather be k'_B as defined at equation **(12)**. Therefore, at the boundaries of the universe, equation **(9)** becomes:

$$T = \left(\frac{15 \cdot h^3 \cdot c^7}{2 \cdot \pi^5 \cdot \left(k'_B\right)^4 \cdot G \cdot A_u} \right)^{\frac{1}{4}} = \left(\frac{15 \cdot h^3 \cdot c^7}{2 \cdot \pi^5 \cdot \left(\frac{k_B}{\beta}\right)^4 \cdot G \cdot A_u} \right)^{\frac{1}{4}} \tag{13}$$

We still have to find the surface area A_u of the luminous universe sphere. Assuming that luminous universe is expanding at the speed of light [8] for a period of time equal to the apparent age of the universe [9], apparent radius R_u thereof is given by:

$$R_u = \frac{c}{H_0} \approx 1.3 \times 10^{26} \text{meters} \tag{14}$$

If the universe was static (but, we will see that **this is not the case**), the equation for the surface area would be:

$$A_u = 4 \cdot \pi \cdot R_u^2 \quad \text{(For a static universe)} \tag{15}$$

Applying this hypothesis to equation **(13)**, this would lead to an average temperature *T* of 31.9 ºKelvin. This assumption is obviously false since the measures presented by Fixsen [6] show that the temperature of the cosmic microwave background is about 2.72548 ± 0.00057 ºKelvin.

Let us then assume that the universe is rotating. Einstein has already demonstrated that a disc rotating at a speed close to that of light has a circumference greater than a disk of the same radius which would be static [7]. This relativistic effect forces the radius used to calculate the circumference to become:

$$R'_u = \frac{R_u}{\sqrt{1-\frac{v^2}{c^2}}} \quad \text{(For a universe in rotation)} \qquad \textbf{(16)}$$

On a smaller scale, the same phenomenon happens in the electron. The classical electron radius allows finding the true size (relativistic) of the electron in rotation. However, the Compton wavelength of the electron leads to a much greater radius. It is the radius value that the electron would have if it was static. The ratio of these two radiuses gives the fine structure constant α:

$$\alpha = \frac{r_e}{r_c} = \sqrt{1-\frac{v^2}{c^2}} \approx 7.2973525698 \times 10^{-3} \approx \frac{1}{137.0359991} \qquad \textbf{(17)}$$

The rotational speed of the periphery of the luminous universe would be:

$$v = c \cdot \sqrt{(1-\alpha)\cdot(1+\alpha)} \approx 0.999973374 \cdot c \qquad \textbf{(18)}$$

This speed is very close to the speed of light. For an observer located at the center of rotation, the time lag in the periphery of the luminous universe is dilated and the distances are compressed by the Lorentz factor.

So, equation **(16)** becomes:

$$R'_u = \frac{R_u}{\alpha} \quad \text{(For a universe in rotation)} \qquad \textbf{(19)}$$

Therefore, the surface area of the universe from equation Erreur ! Source du renvoi introuvable. becomes:

$$A_u = \frac{4\cdot\pi\cdot R_u^2}{\alpha^2} \quad \text{(For a universe in rotation)} \qquad \textbf{(20)}$$

With the help of **(14)** and **(20)**, equation **(13)** becomes[2]:

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[2] Recent works that we make allowed us to evaluate the Hubble constant to $H_0 \approx 72.09548632 \pm 0{,}000000046$ km/(s·MParsec) and the universal gravitational constant to

$$T = \left(\frac{15 \cdot \alpha^2 \cdot h^3 \cdot \beta^4 \cdot c^5 \cdot H_0^2}{8 \cdot \pi^6 \cdot k_B^4 \cdot G} \right)^{\frac{1}{4}} \approx 2.73 \pm 0.03\,^{\circ}\mathrm{K} \qquad \textbf{(21)}$$

Mr. Fixsen calculated the statistical combination of different measures of the average temperature of the cosmic microwave background. These measures come from, among others, the WMAP project of the NASA [6]. According to these measures, the average temperature T of the cosmic microwave background is:

$$T \approx 2.72548 \pm 0.00057\,^{\circ}\mathrm{K} \qquad \textbf{(22)}$$

We see that equation **(21)** is confirmed by this result. Note that the large uncertainties in equation **(22)** come from the fact that Hubble constant H_0 is not precisely known.

2.4. Calculation of Hubble Constant

It becomes obvious that the uncertainty on the average temperature of the cosmic microwave background as measured by NASA is far smaller than the uncertainty of the Hubble constant.

If the theory leading to equation **(21)** is correct, it becomes possible to match this equation to the result obtained in equation **(22)**. This makes it possible to isolate the Hubble constant H_0 from the equation so you can calculate it from parameters that are far more precise.

So, let's isolate H_0 from equation **(21)**:

$$H_0 = \frac{\pi^3 \cdot T^2 \cdot k_B^2 \cdot \sqrt{\dfrac{8 \cdot G}{15 \cdot c^5 \cdot h^3}}}{\beta^2 \cdot \alpha} \approx 71.50 \pm 0.03\,\mathrm{km/(s \cdot MParsec)} \qquad \textbf{(23)}$$

This equation reduces uncertainty by a factor of 47 compared to the last measurement of $H_0 \approx 70.4 \pm 1.4$ km/(s·MParsec) presented by the WMAP project team from the NASA [2] and reduces the uncertainty of a factor of 43 compared to the result of the David Rapetti's research team [1] which presents a Hubble constant that is around $H_0 \approx 71.5 \pm 1.3$ km/(s·MParsec).

$G \approx 6.67323036 \pm 0{,}00000030 \times 10^{-11}$ m^3/(kg·s^2). This situation allowed to revaluate the average temperature of the CMB to $T \approx 2.7367951 \pm 0.0000026$ °K [17].

As the Hubble constant is commonly used in astrophysics to determine the broad parameters of the universe, we propose to replace its measurement by the accurate measurement of the average temperature of the background radiation of the universe. The value of the Hubble constant is then determined by calculation.

Whatever the techniques utilized to measure the Hubble constant, the method used to measure the temperature of the background radiation of the universe seems much more simple and accurate.

2.5. Calculation of the Average Density of the Universe

In mathematics, the volume of a sphere of radius R is given by:

$$V = \frac{4}{3} \cdot \pi \cdot R^3 \qquad \textbf{(24)}$$

However, due to the relativistic effect described by Einstein, when the sphere is rotating at a speed close to the speed of light, the volume of the sphere increases without seeing its radius increasing. Using **(19)**, the volume of the sphere of the luminous universe will be:

$$V_u = \frac{4}{3} \cdot \pi \cdot \left(\frac{R_u}{\alpha} \right)^3 \qquad \textbf{(25)}$$

Using equations **(7)**, **(14)** and **(23)**, the average density σ_u of the universe will be:

$$\sigma_u = \frac{m_u}{V_u} = \frac{3 \cdot \alpha^3 \cdot H_0^2}{4 \cdot \pi \cdot G} \approx 7.4643 \pm 0.0002 \times 10^{-33} \text{kg/m}^3 \qquad \textbf{(26)}$$

We recognize that this value is well below the value currently displayed in the current scientific literature. But this is because it takes into account that the universe is rotating.

3. CONCLUSION

In this work, we show that the universe is rotating. This assumption allows to find (assuming a Hubble constant that would be $H_0 \approx 71.5 \pm 1.5$ km/(s·MParsec) [1]) an equation to calculate the average temperature of the cosmic microwave background $T \approx 2.73 \pm 0.03$ ºK from the fundamental parameters c, h, G, α, k_B, and H_0.

Based on the fact that the temperature of the cosmic microwave background made by the WMAP project of the NASA [2] has much less uncertainty than the measurement of Hubble constant, we used the equation found previously to calculate Hubble constant based on the basic parameters c, h, G, α, k_B, and T. This allowed us to find a calculated value of Hubble constant with far less uncertainty than the value measured by the WMAP team [2] and the Fixsen's team [6]. We therefore propose that the new value of the Hubble constant to be used from now on should be $H_0 \approx 71.50 \pm 0.03$ km/(s·MParsec).

A more accurate value of the Hubble constant H_0 allows multiple equations of astrophysics to gain precision. Moreover, knowing that the universe is rotating opens new avenues of research on the origins of the universe.

The fact that the universe is in rotation affects the average density. According to our calculations, we obtain an average value of $7.4643 \pm 0.0002 \times 10^{-33}$ kg/m^3.

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