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Gravity. Origin and Quantum Evolution of the Cosmos

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Abstract: The most widely accepted hypothesis regarding the birth and evolution of the Cosmos is the Big Bang theory, which states that, before the beginning, all the current mass energy of the Cosmos was already concentrated within an extremely small, dense, and hot singularity. However, in this article, we propose a new model resulting from physical-mathematical deductions and the discovery of a new formula, with the aim of providing a paradigm shift, suggesting that the Cosmos, starting from null mass-energy, creates a Planck mass every Planck time throughout its existence and where gravity is the prime cause of everything. It is responsible for the birth and quantum evolution of the Cosmos.

Keywords: Gravity, Cosmology, Astrophysics, Big Bang

Introduction

Since Edwin Hubble demonstrated that the Cosmos is expanding (Hubble, 1929), the prevailing idea among scientists and educated individuals in the late 19th and early 20th centuries regarding the birth and evolution of the Cosmos, namely a "static and eternal Cosmos," without changes, without a beginning or an end in time, collapsed and new hypotheses had to be established.

The Russian scientist Alexander Alexandrovich Friedman had already anticipated Hubble by establishing, through mathematical deductions, that the Cosmos could not be static and unchanging. Friedmann was the first person to fully understand the equations and the meaning of General Relativity and he even surpassed Einstein in the perception of the concept contained in those magnificent formulas, stating that the cosmological constant that Einstein had introduced "ad hoc" was meaningless and, consequently, the Cosmos could not be static and unchanging (Friedman, 1922).

Unaware of Friedmann's previous work, the Belgian Jesuit priest Georges Lemaître also anticipated Hubble's discovery. Based on the equations of General Relativity, Lemaître reached conclusions similar to those of Friedman regarding an expanding Cosmos and presented the "hypothesis of the primordial atom" or the "cosmic egg." According to this theory, all the mass energy of the current Cosmos was inside an extremely small, dense, and hot singularity before the beginning, and after a sort of explosion, an expansion began that continues to this day (Lemaître, 1979).

With Edwin Hubble's discovery, it became clear that alternatives to the idea of a static and eternal Cosmos had to be sought. To satisfy the idea of an expanding Cosmos, Fred Hoyle established the hypothesis of the "Steady State Universe": An expanding Cosmos where mass is continuously created to maintain a constant density (Hoyle, 1948).

Later, the Ukrainian physicist George Gamow, who had been a student of Friedman, refined Lemaître's ideas by proposing the hypothesis of the explosion of a "Ylem," a gaseous mixture of neutrons, protons, and electrons in an extremely tiny, dense and hot space, leading to the Big Bang model (Gamow, 1948).

The big bang with inflation is currently the most academically accepted model, but it is not a completely satisfactory hypothesis. There are many details that are not fully convincing and raise scientific skepticism. Without being exhaustive, let's consider some of them.

To begin with, the fact that the Big Bang lacks physical-mathematical formulations to support it shows that it is a "speculative model." Secondly, the assumption that all the mass energy of the current Cosmos was already inside an extremely small, dense, and hot singularity before the beginning raises further questions.

In addition, when the "Planck Density" is defined, it is said to be the highest density that has ever existed, which means the density the Universe had at the Planck Time. However, this extremely high density is obtained by dividing the Planck mass by the Planck volume. If we assume that all the mass of the current Cosmos was already present from the beginning, why is only a Planck mass considered and not the mass of the entire Cosmos?

Moreover, a similar situation arises with the so-called "Planck Temperature," the temperature attributed to the Cosmos at the Planck time. This is obtained using the Boltzmann Constant, but in the calculation, only the energy of a Planck Mass is attributed to the Cosmos at that moment, not the energy of the entire current Cosmos as implied by the big bang.

Finally, most cosmologists currently admit that the geometry of the Cosmos is flat and governed by Euclidean geometry. For this to be possible, its density must match the so-called "critical density" not only at a certain moment but throughout its evolution. The critical density has been calculated and is determined by $\rho_c = \frac{3H^2}{8\pi G}$, which can be simplified to $\rho_c = KH^2$, where "K" encompasses all constants and "H" represents the "Hubble Constant," which is not truly a constant. When expressed in homogeneous units, it is equivalent to the inverse of the age of the Cosmos at the time considered "t":

$$H = \frac{1}{t}; \rho_c = \frac{K}{t^2}$$

Density is the quotient between a mass and the volume it occupies. The mass energy of the Cosmos according to the Big Bang is constant and the volume depends on its expansion parameter. According to the Big Bang hypothesis, in order for the condition $\rho_c = K/t^2$ to hold, the scale factor of the radius must evolve proportionally to $t^{(2/3)}$. This way, the volume will be proportional to t^2 and will meet the requirement of $\rho_c = K/t^2$.

However, a parameter with the value of $t^{(2/3)}$ implies a significant negative acceleration, which contradicts current ideas of a Cosmos with time-proportional, or even accelerated expansion. This poses a challenge when attempting to reconcile these two ideas.

We have presented a small sample of reasons that raise concerns about the big bang model, as well as the precautions to be taken regarding the biases we intensely learned and internalized, as it also happened to Albert Einstein with his equations and the model of the "static and eternal Cosmos."

In order to avoid the idea that all mass energy had to preexist at the beginning of everything, alternative theories were presented, suggesting that the entire Universe could have emerged from a vacuum fluctuation without violating conservative laws, as the positive energy of mass is balanced by negative gravitational energy (Fomin, 1975; Tryon, 1973). Alexander Vilenkin also contributed to the theory that the Universe was created from nothing through a quantum leap without altering energy (Vilenkin, 1982).

Later, Krauss (2012) insisted on the idea that the Cosmos must have a total energy of zero, although it has never been proven. He expressed it as follows:

"*In quantum gravity, the Universe can and does spontaneously appear from nothing. These universes do not need to be empty but can contain matter and radiation as long as the total energy, including the negative energy associated with gravity, is zero*"

All these difficulties and inconsistencies disappear in our proposed model.

Gravity is the First of the Interactions

The scientific community widely accepts the existence of four fundamental interactions in nature, each with its own timeline. Gravity, the first of these interactions, emerged near to the Planck time, at around 10^{-44} seconds after the beginning of everything. Approximately at 10^{-37} seconds, the Strong Nuclear Force became independent as a distinct interaction. Finally, at 10^{-12} seconds, the Electromagnetic Force and the Weak Nuclear Force separated.

As a result, the Electromagnetic Force, which is responsible for light, i.e., "c" (the speed of light), is a consequence of the last separation among these interactions. If we assume that the propagation speed of gravitational fields, denoted by the symbol "@", is identical in magnitude to the speed of light in a vacuum, "c", as confirmed by Abbott *et al.* (2017) and knowing that gravitational fields preexisted electromagnetics at the origin, we must accept that "@", the speed of gravitational field propagation, is the cause and "c" is the consequence, or that both are consequences of a common earlier cause. Since Gravity is considered the first interaction to appear in the Cosmos, the speed of gravitational field propagation "@" should be taken as the true cause and the authentic "universal speed constant" in place of "c".

We recognize the historical significance of "c" as a fundamental quantity accepted in Physics. Given that the quantitative value of "@" and "c" is identical, in many cases the substitution may not be justified. However, since they are conceptually different, it provides two fundamental advantages in our model, as we will indicate. Furthermore, this substitution can be crucial in the development of new research.

Planck Units

Planck established the units that bear his name, the Planck Mass "m_P", the Planck Time "t_P" and the Planck Length "l_P" defined by:

$$m_P = \sqrt{\hbar c/G}; t_P = \sqrt{\hbar G/c^5}; l_P = \sqrt{\hbar G/c^3}$$

We must remember that from 10^{-44} to 10^{-12} seconds the electromagnetic interaction had not decoupled, therefore the constant "c" cannot be used in a period in which it did not exist and consequently the Planck Units are not applicable in this time interval. This strengthens our proposal to generalize the substitution of "c" by "@" that existed from the beginning.

These units must be expressed after substituting "c" for "@" according to:

$$m_P = \sqrt{\hbar @ / G}; t_P = \sqrt{\hbar G / @^5}; l_P = \sqrt{\hbar G / @^3}$$

The Cosmos in the Planck Time

After the indicated substitution, the quotient between the Planck mass and the Planck time provides us with the expression:

$$m_P / t_P = @^3 / G \quad (1)$$

Solving for "m_P" we obtain:

$$m_P = @^3 G^{-1} t_P \quad (2)$$

This is a straightforward expression, which at first glance can be interpreted as a relationship between the Planck mass and the Planck time. However, it can also hold a profound significance, indicating that the two universal constants characteristic of gravity, "@," and "*G*," provide us with a Planck Mass in a Planck time, which is the mass-energy that the Cosmos had at the Planck time. This perspective aligns with the paper "Gravity, the Origin of the Mass in the Cosmos" (Alemany and Villarroya, 2021).

When we use the term "mass-energy," we are referring to the energy of mass plus radiation energy, without considering gravitational or kinetic energies.

We can wonder about the space that this primordial mass energy occupied. Considering "@" as the speed of gravitational field propagation and " t_P" as the elapsed time, in Euclidean space, logically leads us to assume that in Planck time, the cosmos must have been a sphere with a radius "R_P" equal to "@t_P", which turns out to be identical to a Planck length " l_P":

$$R_P = @ t_P = l_P \quad (3)$$

The Cosmos in the Planck time will possess an energy Em_P = $m_P @^2$ according to (2), it is:

$$E m_P = @^5 G^{-1} t_P \quad (4)$$

The above allows us to establish a model in which the initial Cosmos at the Planck Time is constituted by:

- A mass-energy equivalent to a Planck mass inside a sphere with a radius equal to a Planck length
- This initial cosmos was a consequence of a quantum leap, from which gravity and time emerged

This new paradigm for the initial Cosmos eliminates several of the inconveniences and inconsistencies pointed out for the big bang hypothesis, as it does not require all the mass-energy to be present before the beginning of everything. It also provides coherence to the definitions of "Planck density" and "Planck temperature" by establishing that at the Planck time, the entire mass-energy of the Cosmos was precisely one single Planck mass.

The Equation of Mass-Energy of the Cosmos

We are aware that extrapolating equations can be risky, however in this case it can be justified. Assuming that time can only be expressed in multiples of "Planck quanta" or Planck times, by multiplying both terms of Eq. (2) by a positive integer "*N*," we obtain:

$$N m_P = @^3 G^{-1} N t_p \quad (5)$$

This simple equation, expressed in terms of mass, shows us how the mass-energy of the Cosmos was born and evolved. It indicates that in this model, at time zero, the mass-energy of the cosmos was null. at one Planck time, the mass-energy was that of a Planck Mass and at two Planck Times, it was two Planck Masses and so on, extending from the Planck Time through the present and into the future.

According to this model, Eq. (5) clearly shows us the quantum birth and growth of the Cosmos. Its mass-energy "$N m_P$" grows by one Planck Mass for every "N t_P" Planck time.

If we make the substitutions in Eq. (5): $M = N m_P$ and $t = N t_P$ to work in standard units, we have the equation for the mass-energy of the Cosmos:

$$M = @^3 G^{-1} t \quad (6)$$

Here, "*M*" represents the mass-energy of the Cosmos expressed in mass, "@" the speed of gravitational field propagation, "*G*" the universal constant of gravity, and "*t*" the time elapsed from the beginning of everything up to the considered moment whether in the past, present, or future, expressed in seconds.

With E_P as the Planck energy, Eqs. (5-6) expressed in terms of energy become:

$$E = N E_P = @^5 G^{-1} N t_p \quad (7)$$

$$E = @^5 G^{-1} t \quad (8)$$

While it may seem like a risky extrapolation, in this case, it is justified because the general Eq. (6) has been obtained through various procedures detailed in the paper "Gravity, the Origin of the Mass in the Cosmos" (Alemany and Villarroya, 2021).

To determine the radius of the space occupied by mass energy, if we multiply both terms of expression (3) by the positive integer "*N*," we obtain:

$$N R_P = @ N t_P = N l_P \quad (9)$$

This shows us the quantum growth of the Cosmos' radius, which is one Planck length for every Planck time.

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If we make the substitutions in Eq. (9): $R = NR_P$ and $t = Nt_P$, we have the radius of the Cosmos as a function of time "t" whether in the past, present, or future:

$$R = @t \quad (10)$$

The mass at rest "M" will have an energy "E_M":

$$E_M = M@^2 \quad (11)$$

The interpretation of Eqs. (6 and 10) provides a different view of the Cosmos than the one defended by the Big Bang model since the proposed "quantum gravitational model," states that.

For time "$t = 0$," the mass of the Cosmos was "$M = 0$" and the radius "$R= 0$".

Mass-energy and radius grow proportionally with time, by one Planck mass and one Planck length for every Planck time. Thus, it provides the history of the evolution of the mass-energy and the radius of the Cosmos.

Gravity is the generative cause of mass energy.

The equation for the mass-energy of the Cosmos, according to our model, resolves the difficulty that we mentioned earlier regarding the "critical density"$\rho_c = K/t^2$ and the Big Bang model. Since in the calculation of density, in the numerator, the mass of the Cosmos grows proportionally with time, and in the denominator, the volume grows cubically with time, the density decreases proportionally with the square of time, as indicated by the "critical density", which must hold throughout the entire evolutionary process of the Cosmos.

Now, we can justify the substitution of the universal constant "c" with "@". Failure to do so would express the general formula (6) as "$M = c^3G^{-1}t$" and would depend on two interactions, electromagnetic "c" and gravity "G". This way, it depends only on two constants, "@" and "G" of the same interaction, Gravity. Furthermore, if we did not make this substitution, the application of the formula would be compromised in the period before 10^{-12} seconds, i.e., during 1.85×10^{31} Planck Times, due to the absence of electromagnetic interaction and consequently "c" during that time. A crucial time for the birth and evolution of the Cosmos.

The Total Mass-Energy and Radius of the Cosmos

Every Planck Time generates a Planck Mass in the Cosmos.

One Planck Time, or Planck quantum, is $t_P = 5.39\times10^{-44}$ seconds. Therefore, one second has 1.85×10^{43} quanta of time originating from 1.85×10^{43} Planck masses.

The Planck mass is equal to 2.18×10^{-8} kg, which is equivalent to 1.22×10^{28} eV. This corresponds to an increase in mass energy of 4×10^{35} kg every second. Given that the mass of the Sun is 2×10^{30} kg (Martínez, 2005), this equates to an increase in mass-energy equivalent to 200,000 Suns per second.

This growth has continued at the same rate since then, providing, for an age of approximately 13.7 billion years of the Cosmos, a mass of 1.73×10^{53} kg, or 8.64×10^{22} Suns. These values are similar to current estimates, which are on the order of 10^{53} kg (Valev, 2014) or 10^{22} Suns. This evidence strongly supports the validity of the "Quantum Gravitational Model" according to our proposal. Considering that the age of the Cosmos is on the order of 4.32×10^{17} seconds and each second contains 1.85×10^{43} Planck Times, the age of the cosmos is about 7.99×10^{60} Planck Times. Consequently, according to our model, the total mass of the Cosmos in relation to the Planck Mass and the total radius of the Cosmos in relation to the Planck Length should be affected by a factor of 7.99×10^{60}. This value is close to 5.73×10^{60}, which was obtained by Dr. Dimitar Valev using different reasoning to test Dirac's large numbers hypothesis (Valev, 2019).

The Formation of Particles

Over the course of 13.7 billion years, Planck Masses, each containing energy packets of 1.22×10^{28} eV, have been emerging in the Cosmos. These high-energy packets expand and cool down, successively fragmenting into other packets of lower energy and photons.

In this energy descent ladder, there will come a moment when the energy of these packets approaches that of a specific particle. In that case, this energy can transform into that particle, which can be either stable or unstable, in which case it would continue to decay into others.

In this manner, the majority of the energy from the 1.22×10^{28} eV packets can be converted into astroparticles, particles, and photons, following the descending energy pattern of these packets. Considering that the energy of a neutron is 9.39×10^{8} eV, the maximum number of neutrons that each "m_P" can generate is approximately 1.3×10^{19} neutrons. The fragmentation of some of these neutrons will produce protons, electrons, and antineutrinos, resulting in an equal number of protons and electrons with opposite charges, explaining the overall neutrality of the total charge.

Conservation of Energy

Equation (6) states that the mass-energy of the Cosmos grows proportionally with time, giving the impression that it violates the law of energy conservation.

We can express this equation as the sum of radiation energy and mass-energy in the following way:

$$E + M@^2 = @^5G^{-1}t \quad (12)$$

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If we multiply and divide the second term of the equation by "$@$" "G" and "t" we have:

$$E + M@^2 = G\frac{@^6 G^{-2} t^2}{@t} \; ; \; E + M@^2 = G\frac{M^2}{R}$$

When expressed as:

$$E + M@^2 - G\frac{M^2}{R} = 0 \quad (13)$$

It indicates that the term:

$$G\frac{M^2}{R} \quad (14)$$

Compensates for all the growing mass-energy over time. Term that takes the form of mechanical energy, which should encompass potential gravitational and kinetic energies.

Materials and Methods

This theoretical study is based on critical scientific reasoning derived solely from the use of Physics and Mathematics.

Results and Discussion

In our previous paper, Gravity: The Origin of Mass in the Cosmos (Alemany and Villarroya, 2021), we showed that the mass-energy of the Cosmos increases proportionally with time, at a rate equivalent to approximately 200,000 suns per second."

In the present work, we move forward by showing how this origin and evolution occur in a quantum manner, demonstrating that, starting from zero mass-energy, the Cosmos grows-at each "quantum of time"-by one Planck mass in mass-energy and one Planck length in radius.

These findings will undoubtedly reshape established ideas and contribute to a deeper understanding of the Cosmos.

Conclusion

We propose that the speed of gravitational field propagation, represented by "@", should be considered the true universal speed constant. Light has experienced two delays when propagating in relation to gravity: The first one is approximately 10^{-12} seconds, the time it takes for the Electroweak Interaction to break down and give rise to the Electromagnetic Force, and the second one during a period of about 400,000 years, when the hot plasma did not allow light to propagate. These two time delay intervals occurred while the spherical gravitational field containing the Cosmos expanded its radius at the speed of "@" without any obstacles. Therefore, we propose that the term "*gravity years*" should be used instead of "light years" to define the size of the Cosmos.

We reject the part of the Big Bang theory that claims that the entire mass-energy of the current Cosmos already existed in a singularity before the beginning of everything. Having all the necessary mass-energy before the start means a "beginning with almost everything already done." Additionally, this hypothesis lacks physical-mathematical support, which should concern critical scientific thinking.

We have succeeded in providing an alternative to the process of birth and formation of the Cosmos. At time zero, the mass and radius of the Cosmos are zero, but in the first "quantum of time," they reach the mass energy of a Planck Mass and a radius equal to a Planck Length. This occurs thanks to a quantum fluctuation in which Gravity and Time appear. We argue that instead of a "Big Bang," there was a "*Planck Bang*" at the beginning. From this moment on, in the Cosmos, every "quantum of time" mass-energy increases by one Planck Mass and the radius increases by one Planck Length.

The current Cosmos is a gravitational sphere with a radius of 13.7 billion "*gravity years*" and inside it, there is mass-energy equivalent to 1.73×10^{53} kg.

In this quantum birth and evolution of the Cosmos, Gravity plays the leading role, supported by its two constants, "G" and "@," along with time "t." Gravity shifts from being a "*consequence of*" to be "*the primary cause of everything*".

We must insist on warning readers that, given the great change that the new paradigm represents, they may feel a natural intellectual rejection, either doubting the proposed mathematical demonstration or denying the existence of data or indications that legitimize it.

If the doubt is in relation to the deduction set forth in this article, we advise you to consult (Alemany and Villarroya, 2021) "Gravity, the Origin of the Mass in the Cosmos" where you will find various physical-mathematical demonstrations, which by different routes come to converge in the same equation as the one set forth in this article and if it is in relation to indications or data that justify it, we must point out that, despite the novelty of the proposal, we already have data and evidence in its favor as we have seen:

- The calculated mass of the Cosmos according to the equation obtained is of the same order of magnitude as that currently estimated by other methods
- That a single Planck mass is used in the calculation of the Planck density is in accordance with our proposal and not with the Big Bang model
- That a single Planck mass is used in the calculation of the Planck temperature is in accordance with our proposal and not with the Big Bang model
- That a detailed study of the Critical Density equation is also in accordance with our proposal and not with the Big Bang model

A whole series of inconsistencies that the Big Bang model presents disappear in the proposed model, which is also the result of mathematical deductions and not speculative hypotheses.

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Ethics

The authors will address any ethical issues that may arise after the publication of this article.

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