

QUANTUM-GRAVITATIONAL THEORY

The true nature of the gravitational force still remains unknown. Its effects are correctly described by Newtonian theory and *general relativity*, but both only tell us that it resides in mass. The greater the mass, the greater the gravitational force. For the last 50 years or so, the scientific community has been trying to reconcile the *theory of general relativity* with the *quantum-mechanical theory*, without success so far. And one of the most recent proposals defines it as an emergent force associated with the entropy of the universe [1][2].

On the other hand, from the *standard model of physical particles*, the graviton, *as its transmitting particle, is included within the boson family*, thus introducing its possible quantum nature. But their experimental verification has not been verified.

With this article we begin the presentation of the *Quantum-Gravitational Theory* starting from two premises:

1. Newtonian and relativistic theories only describe the gravitational effects of mass.
2. The gravitational properties attributed to mass reside in its fundamental components: *nucleons*.

In this, the first of a series of three, we expose its *quantum-mechanical formulation* where nucleons (protons and neutrons) *are attributed the origin of the quantum nature of the gravitational force*.

The mass of the *proton's valence quarks*(*u,d*) is less than 2% of its total mass. The only proposals to explain this fact come from QCD, which attributes the remaining 98% of mass to the energy generated by *gluons* and *s-quarks (without valence)*, generated within it.

Our proposal attributes it to a *harmonic-quantum oscillation* of the quarks that make up nucleons and the subsequent emission of *gravitational pulses* that are transmitted to the medium in the form of *gravitational quanta*℄. It is how baryonic matter manifests itself and gravitationally binds.

This implies a new vision of *Newtonian theories* and *general relativity*, without this implying their questioning, as will be seen in the next articles on the *quantum-Newtonian formulation* and the *quantum-relativistic formulation*.

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Quantum-mechanical formulation or of isolated matter

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Nature only uses three elementary particles to create matter: *the quarks u , d , and the electron*. These *quarks*, through a process called *hadronization*, in turn form the only stable *hadrons* known as *baryons*: the *proton* and the *neutron*. Everything we see and know is essentially made up of these two particles, more commonly called nucleons, since they are the ones that make up the *atomic nucleus*.

If we consider any mass, M , more than 95% is provided by its *nucleons*, since the mass of the *electron* is about 1,835 times less than that of the *proton*. And in turn, the quarks(u,d) that make up the *nucleons* only represent less than 2% of it.

Where is the remaining 98%? The only current theoretical proposal to give an answer comes from **QCD** and is based on the contribution of the *non-valence s -quark* together with the due contribution of *the gluon interaction*. Among the different studies, we highlight the one carried out by Xjangdong Ji (October 1994) [3] supported by the MIT bag model and Johnson, K. (1975) [4]. There are also many experimental tests: Silva P.R. (August 2011) [5], Thomas A.W. (February 2012) [6], Mever H.B. (February 2011) [7] and Horsley R. et al. (October 2011) [8], all with mixed results. But what they do agree on is that 2/3 of the proton's mass is due to the energy of *non-valence quarks and gluons*. But despite these theoretical efforts there is nothing conclusive to explain 93% of our mass M .

On the other hand, the gravitational effects that our mass M produces are correctly described by Newtonian theories and *general relativity*, but both are limited to describing and predicting these effects on other masses and only indicate that the gravitational force has its origin in the mass M .

With this article we begin the proposal of a *quantum-gravitational theory*, which would try to answer the origin and nature of the gravitational force, assigning the *nucleon* and its internal structure the leading role in ways far removed from the **QCD**.

This first installment dedicated to the *quantum-mechanical formulation* is divided into three chapters:

1. The *quantum-harmonic oscillation* of *quarks* in *hadrons*.
2. The *gravitational pulse of matter* (PGM) and the *gravitational quantum* $\mathfrak{E}$.
3. The *gravitational vector* of matter.

Finally, it should be noted that the following exposition is a first part referring to isolated matter. This means that we perform the mental exercise of placing a nucleon as the only matter in the universe. The reasons for proceeding in this way will be understood in the following article dedicated to the *quantum-Newtonian formulation*, where the fundamental relationship between matter is exposed.

I. The Quantum-Harmonic Oscillation of Quarks in Hadrons

The *quantum Hamiltonian* of a particle of mass m subjected to a quadratic potential has the form of: $V_x = \frac{1}{2}Kx^2$

$$\hat{H} = \frac{\hat{p}^2}{2m} + \frac{1}{2}m\omega^2 x^2 \quad (1)$$

where x is the position operator, and p is the moment operator: $\hat{p} = -i\hbar \frac{d}{dx}$

And the *time-independent* Schrödinger equation for a *quantum-harmonic oscillator* is [9]:

$$H\psi_{(x)} = \left[-\frac{\hbar^2}{2m} \frac{d^2}{dx^2} + \frac{1}{2}m\omega^2 x^2 \right] \psi_{(x)} = E_p \psi_{(x)} \quad (2)$$

The general formula for the wave function, ψ , normalized is:

$$\psi_n(x) = \left(\frac{\alpha}{\pi}\right)^{1/4} \frac{1}{\sqrt{2^n n!}} H_n(x) e^{-x^2/2} \quad (3)$$

where $H_n(y)$ are the *Polynomials of Hermite*.

Solutions to the *Schrödinger equation* show discrete and time-independent energy levels as eigenstates or eigenvalues of the wave function ψ .

$$E_n = \left(n + \frac{1}{2}\right) \hbar\omega \quad n = 0, 1, 2, \dots \quad (4)$$

Figure 1: Quantum harmonic oscillator energy levels

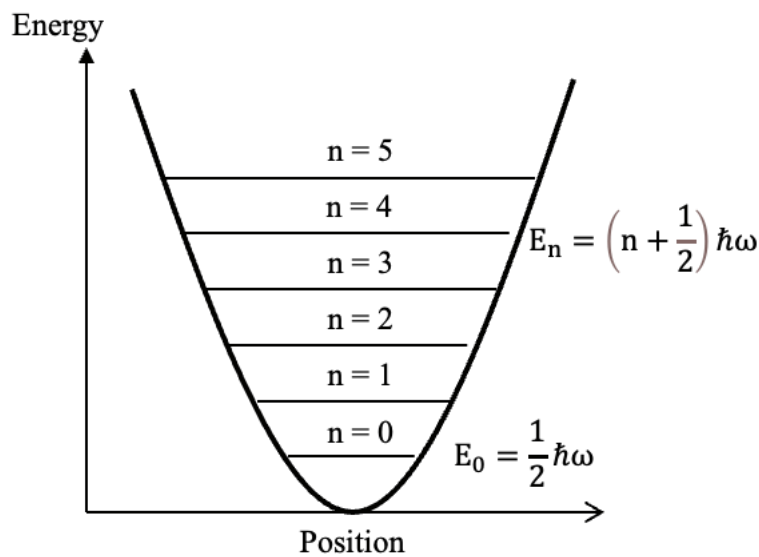
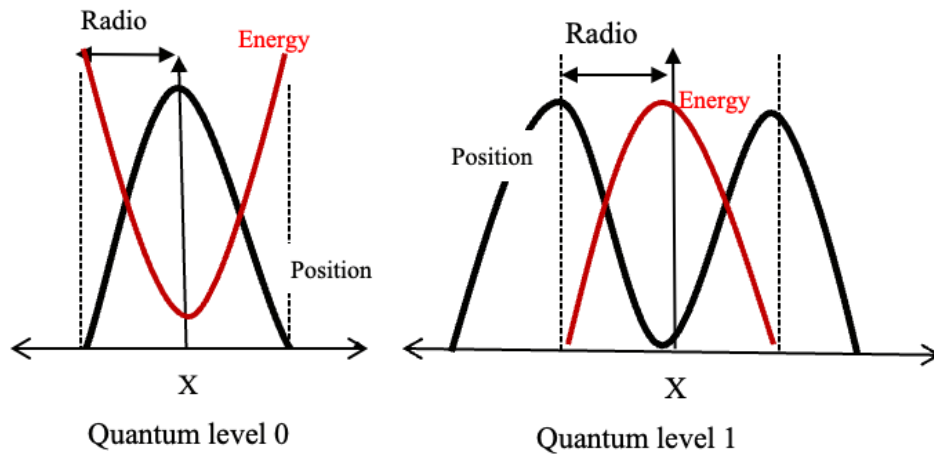


Figure 1 shows the different levels quantized as a function of energy. Quantum jumps are normalized to $\hbar\omega$.

The zero-point energy of a *quantum harmonic oscillator* is nonzero and has the value. His deduction is based on $\frac{1}{2}\hbar\omega$ Heisenberg's uncertainty principle [10] and was first proposed by Albert Einstein and Otto Stern (1913) [11].

The *Quantum-Gravitational Theory* proposes that the three quarks of the *nucleons* are bound by the action of the *strong nuclear force* in a state of quantum oscillation between two eigenstates of energy. Its behavior corresponds to a *quantum harmonic oscillator* between two energy levels: E_{min} ($n = 0$) and E_{max} ($n = 1$).

Figure 2: Density probabilities
Proton Quark Position and Energy



The probability densities for the first two energy levels of a *quantum-harmonic oscillator* are shown in Figure 2.

The experimental measurements of proton mass and radius are 0.938272089436 GeV/c² [12] and 0.833±0.010 fm [13][14], respectively. It has also been found that the *strong nuclear interaction* becomes strongly repulsive below 0.4 fm, so that quarks are confined within these limits.

At the quantum level 0 or low energy, the maximum quantum probability of finding the quarks of the proton is at their center or minimum radius (0.4, fm), with their probability of minimum energy. Conversely at their quantum level 1 or maximum energy probability, quarks will be found with maximum quantum probability at their extremes or maximum radius (0.833 fm). According to the densities of probabilities, the experimental measurements of the mass and radius of the proton correspond to its quantum level 1, or maximum energy and radius.

Figure 3: Proton quark oscillation

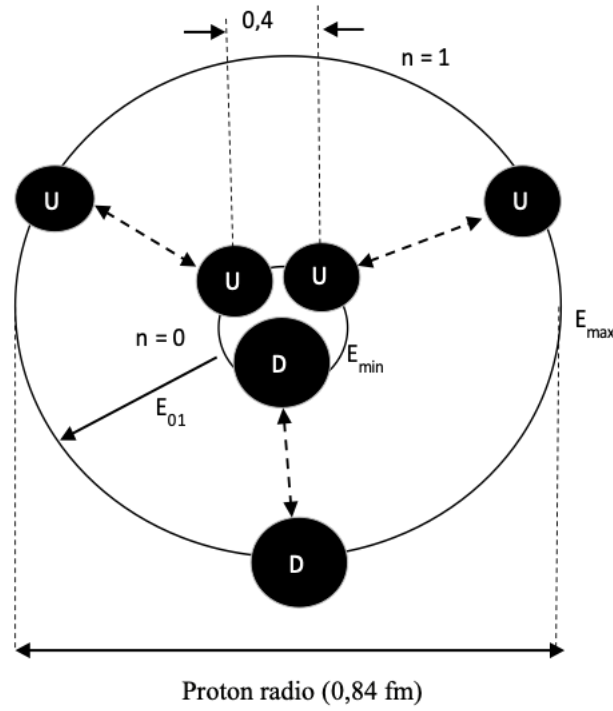


Figure 3 illustrates the distribution of the proton's quarks in their two quantum energy levels.

Experimental measurements of the proton's mass and radius correspond to quantum level 1 of maximum energy and radius probabilities. And the most accurate measurements of the masses of the u and d quarks [15] indicate that they represent only 0.96% of their total mass, which is why *the effects of their mass on nucleons have been neglected* throughout quantum-gravitational theory.

The quarks of the proton are elastically bound by strong *nuclear interaction* exchanging *gluons* and in permanent quantum oscillation between the limits of their confinement, and consequently an energetic oscillation occurs from their level 0 or minimum energy, $E_{min} = 0.31275736314333\frac{1}{2}\hbar\omega$ GeV, to their level 1 or maximum energy $E_{max} = 0.93827208943$ GeV, performing an energy jump of value $E_{01}^3\hbar\omega = \hbar\omega = 0.62551472628667$ GeV with a frequency f of 1.51248786683 1023 hz, deduced from the *Planck/Einstein relationship*, $E = h\nu$

The quantum superposition of both energy eigenstates are *hadrons*, and particularly, *nucleons* as the only stable *hadrons*. The fundamental aspects of the *hadronization process* will be extensively treated by López, P. in the *Naked Quark Hypothesis* [16], as an independent and at the same time complementary theory, currently under preparation.

The energy jump between its two energy levels accounts for approximately 66.66% of its mass, and the remaining 33% corresponds to the energy of the *zero point* or minimum level.

II. The gravitational pulse of matter (PGM) and the gravitational quantum $\mathfrak{G}$

Newton measured the gravitational effects between any two masses within the Earth's gravitational field, and found that it was proportional to their product divided by the square of the distance and by a constant G . Thus, G arises as a constant of adjustment between the force actually measured and the relationship between masses and distance. Its deduction is entirely empirical and devoid of physical significance, but it is necessary in any formulation concerning the gravitational force

$$F_g = G \frac{M_1 \cdot M_2}{d^2} \quad \text{N} \quad (5)$$

In its classic formulation, mass and the gravitational effects it produces are intermingled. We know the final force with which two masses attract each other, but we do not know the origin of that force. And mass is clearly an insufficient answer.

For this reason, we propose to initiate a theoretical-physical reflection, whose objective is to link the *quantum-gravitational theory* with the *classical Newtonian theory*, firstly, to later relate it to *Einstein's general relativity*.

The classical formulation of (5) has been perfectly verified in our *Solar System environment*, and if we assume that G is universal, it implies that it is independent of the medium and therefore can only be related to the masses $M1$ and $M2$.

The simplest way to measure the gravitational force on the surface of a body in terms of acceleration is the well-known gravity or g .

$$g = G \frac{M}{r^2} \quad m \cdot s^{-2} \quad (6)$$

The quantum jump between the two energy levels of the quarks in nucleons with an EPGM value = 0.62551472628667 GeV, is transmitted to adjacent space in the form of a gravitational pulse with quantum information about its origin and nature. It can therefore be defined as a *gravitational charge* inherent in the nucleon, and can be expressed according to its minimum or maximum energy as:

$$\begin{aligned} E_{PGM} &= E_{max} - E_{min} = 3E_{min} - E_{min} = 2E_{min} \\ E_{PGM} &= E_{max} - E_{min} = E_{max} - \frac{E_{max}}{3} = \frac{2}{3}E_{max} \end{aligned} \quad (7)$$

Quantum-gravitational theory proposes a new approach of (6) such that:

$$g = \hat{G} \frac{N}{r^2} E_{pgm} \quad m \cdot s^{-2} \quad (8)$$

Now gravity g is proportional to the number of nucleons N that make up the mass M , and the gravitational constant G is replaced by a new constant $\hat{G}$

By equalizing both equations, (6) and (8), we get:

$$GM = \hat{G}NE_{pgm} \quad (9)$$

Both G and M must be expressed in units of eV.

The above fundamental relation has a clear lower limit when $N = 1$, since it will always be a positive integer that corresponds to the nucleon. Then

$$GM_p = \hat{G}E_{pgm} \quad (10)$$

Or to put it in terms of the oscillation energies of the quarks of the proton:

$$GE_{max} = \hat{G}(E_{max} - E_{min}) \quad (11)$$

So definitely now in terms of maximum energy:

$$\hat{G} = G \frac{E_{max}}{(E_{max} - E_{min})} = \frac{3}{2}G = 1,7847030695296 \cdot 10^{-46} \frac{m^3}{eV \cdot s^2} \quad (12)$$

The new constant can be provisionally interpreted as the transformation relationship between the effective gravitational energy transferred to the medium and the energy emitted by the nucleon. In the following article dedicated to the $\hat{G}$ *Quantum-Newtonian formulation* it will be completely reformulated.

Finally, we define *gravitational quantum* $\mathfrak{E}$ (of isolated matter) as the product of:

$$\mathfrak{E} = \hat{G} \cdot E_{PGM} = 1,1163580520398 \cdot 10^{-37} m^3 s^{-2} \quad (13)$$

The gravitational quantum is the quantum manifestation of the existence of baryonic matter in space-time and the nexus between it and $\mathfrak{E}$.

The relation (9) can be transformed into. $\widetilde{GM} \equiv \widetilde{N\mathfrak{E}}$ (14)

This is one of the most relevant deductions of *quantum-gravitational theory*. He tells us that mass cannot be separated from the gravitational effects that it itself generates in classical terms, since the left-wing term of equality is classical. In order to separate them, we must use the term right that corresponds to quantum-mechanical: the mass M is the quantum superposition of the *gravitational quanta* of their N nucleons. *If it is the quantum manifestation of matter, N is its quantum-gravitational information. tells another matter that it is matter, while N tells it how much matter it is.* $\mathfrak{E}\mathfrak{E}$

The formulation (8) of the theory is now reduced to:

$$g = \frac{N}{r^2} \mathfrak{E} \quad m \cdot s^{-2} \quad (15)$$

From this relationship and from the *Planck-Einstein relationship*, $E = h\nu$, we can obtain:

$$\mathfrak{E} = \hat{G} \cdot h \cdot f_{PGM} \quad (16)$$

From (9) and (12) we can easily deduce M :

$$M = \frac{3}{2} N E_{\text{PGM}} \quad (17)$$

But both the mass obtained with this formulation, and its simple classical measurement, are insufficient by themselves to give us information about our universe. In both cases, the use of a gravitational constant is essential, which gives physical meaning to the mass in a universal framework. And that is what the relationship tells us (14). They cannot be separated $\hat{G}$ y E_{pgm} , since what we measure and perceive is the *gravitational quantum* total of a body given by $N\mathfrak{E}$. The universe is an infinite gravitational field, where all baryonic matter is both participant and receiver.

The superposition of the *gravitational quanta* $\mathfrak{E}$ of all the nucleons in a body, they define their mass M . If we locate the origin of the gravitational mass in the *hadronization* of quarks, and specifically in the formation of the *Proton* with the issuance of its *Gravitational pulse* (PGM), we're also saying that's the temporal origin of gravitational force. Mass is therefore a consequence of the gravitational attraction of baryonic matter.

III. The Gravitational Vector of Matter

We define the gravitational vector of matter as:

$$\vec{V}_g = \frac{1}{d^2} N \vec{\mathfrak{E}} \quad m \cdot s^{-2} \quad (18)$$

If $N = 1$ is ungrouped matter and for values of $N > 1$ is grouped matter.

Its action is exercised in two opposite directions, neither exclusive nor antagonistic:

- For values of $d \geq r$ acts on the rest of the baryonic matter.
- For values of $d < r$ acts on itself as a gravitational eigenvector.

The *gravitational quantum* $\mathfrak{E}$ manifests the nature of which it is baryonic matter and N expresses its magnitude, and must be considered as a *gravitational quantum number*. Now N acquires the meaning of the *gravitational charge* of a macroscopic body, whose information is transmitted by its own *quantum*.

Figure 4

QUANTUM-GRAVITATIONAL STUDY Ag^{107}					
Mass Ag^{107} (Kg)	Nucleons Ag^{107}	E_{PGM} (Ev)	$\hat{G}$ ($m^3/\text{eV} \cdot s^2$)	$\mathfrak{E}$	Proton mass(Kg)
1	5,978637398479E+26	6,2551472628667E+08	1,78470306952957E-46	1,11635805203977E-37	1,6726219259500E-27
Clasic-Newtonian Formulation (eV) 6,674300000000E-11			Quantum-Gravitational Formulation (eV) 6,674300000018E-11		

Figure 4 shows a study carried out on 1 kg of the isotope of Ag107. For simplicity and not to affect the calculation significantly, we have used the mass of the proton as the only nucleon. The value of the radius has been omitted as it does not influence the final result. Both formulations have identical values.

We can easily deduce the relationship between the two:

$$V_g = \frac{N}{r^2} \mathfrak{G} = \frac{N}{r^2} \hat{G} E_{\text{PGM}} = \frac{N}{r^2} \hat{G} \frac{2}{3} M_p = G \frac{M}{r^2} \quad (19)$$

Starting with the *quantum-gravitational formulation* we have arrived at the *Newtonian formulation*. However, the reverse path is not sustained without considering the quantum nature of the gravitational force. The *quantum-gravitational theory* is not the simple transformation of the mass, M of the classical theory into the product of its total nucleons by the individual mass of each of them, but it is the manifestation that each nucleon transmits to space a pulse of matter energy, whose origin is in the *harmonic-quantum oscillation* of its *constituent quarks*. as a *load of matter*.

Quantum-Newtonian formulation or of entangled matter

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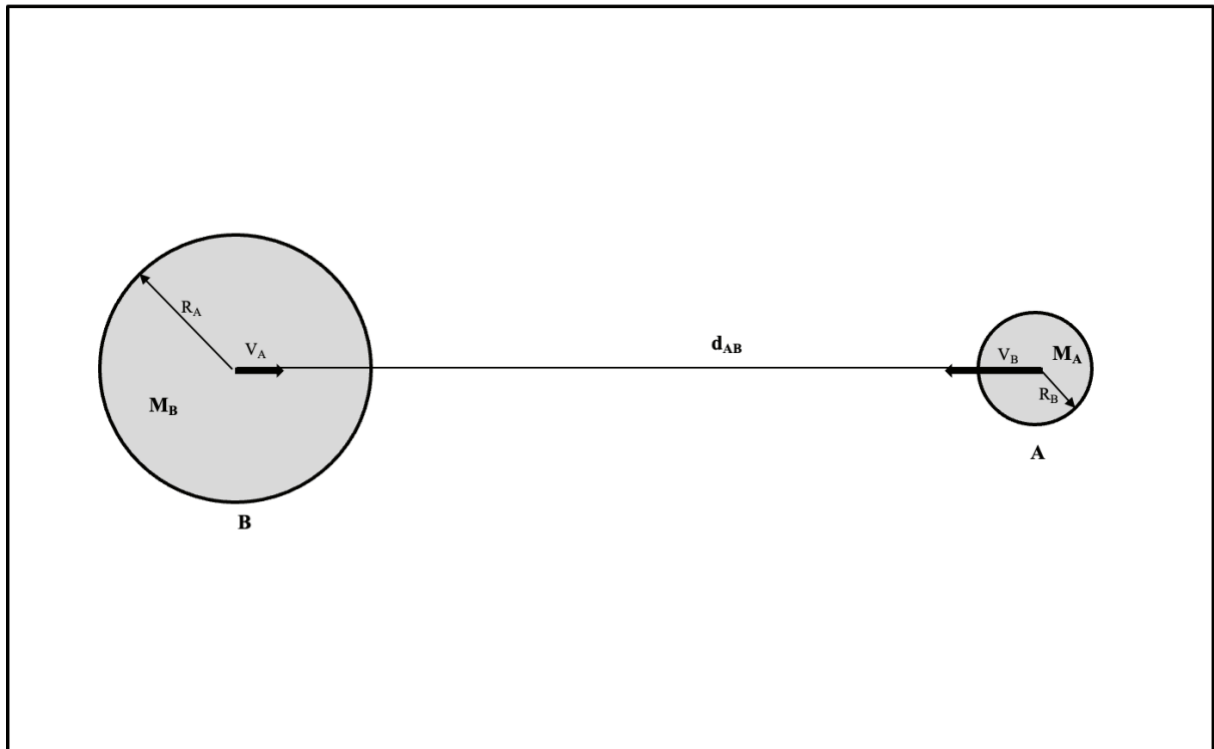
If in the *Quantum-mechanical formulation* We described the quantum origin of the gravitational force and the manifestation as baryonic matter to space in the form of the *Gravitational quantum (from isolated matter)*Ⓔ. In this article we describe and detail the gravitational relationship between macroscopic bodies that, for the sake of expositional simplicity, will be spherical, and their evolution over time. With this we address the *Quantum-Newtonian formulation* which will be divided into several headings:

- The gravitational force: Matter finds matter.
- Entangled matter: Vector and quantum-mechanical analysis.
- The gravitational self-vector.

In this way, we introduce a new vision of the Newtonian conception of gravity, without questioning its fundamental concepts, but rather seeking to delve into the nature of the dominant force in our universe.

I. The Gravitational Force: Matter Finds Matter

Figure 5: Gravitory system between two bodys



Let the static spherical bodies A and B in Figure 5 be the masses M_A and M_B , respectively, and d_{AB} the distance separating their centers of mass. The conditions of the environment are the absence of any other baryonic matter and lack of history.

Newton taught us that the gravitational force experienced by both bodies is described by:

$$F_{GAB} = G \frac{M_A \cdot M_B}{d_{AB}^2} \quad \text{Kg} \cdot \text{m} \cdot \text{s}^{-2} \quad (20)$$

Their respective *gravitational vectors* will be:

$$\vec{V}_A = N_A \vec{\mathfrak{E}} \quad \text{m} \cdot \text{s}^{-2} \quad \vec{V}_B = N_B \vec{\mathfrak{E}} \quad \text{m} \cdot \text{s}^{-2} \quad (21)$$

And the gravitational force expressed in terms of *quantum-gravitational theory* is:

$$\vec{F}_{GAB} = \frac{3}{2} \frac{N_A \cdot N_B}{d_{AB}^2} \vec{\mathfrak{E}} \quad \text{eV} \cdot \text{m} \cdot \text{s}^{-2} \quad (22)$$

for $N_B > N_A$.

Expressing (20) and (22) in units of eV and equalizing, we get:

$$G \cdot M_A \cdot M_B = \frac{3}{2} N_A \cdot N_B \cdot \vec{\mathfrak{E}} \quad (23)$$

$$\text{Being } \vec{\mathfrak{E}} = \hat{G} \cdot (E_{PGM} \cdot E_{PGM}) = \hat{G} \hbar^2 \omega^2 \quad (24)$$

There is actually a transformation at the level of their respective quantum:

$$\vec{\mathfrak{E}} \cdot \vec{\mathfrak{E}} = \hat{G} E_{PGM} \cdot \hat{G} E_{PGM} \lesssim \hat{G} (E_{PGM} \cdot E_{PGM}) = \vec{\mathfrak{E}} \quad (25)$$

The relations of (24) and (25) are the manifestation of the *gravitational entanglement* of matter, the expression of which is the *universal gravitational quantum (of entangled matter)*. $\vec{\mathfrak{E}}$ From here on out we will only use this notation. Baryonic matter recognizes each other and becomes gravitationally entangled. Now the new *universal gravitational quantum* takes on the units of energy and takes on a unique character, as it manifests itself in nature.

The concept of *gravitational entanglement* had already been anticipated by Vijay Balasubramanian et al. [17] within the QFT, and later by Sougato Bose et al. [18],[19]. And very recently, entanglement effects have been verified by the ATLAS detector of the LHC [20] and in digital simulations inside an IBM computer by Carlos Sabín [21]. Other contributions come from Marios Christodoulou et al [22]. The application of the quantum concept of entanglement to gravitational attraction is not new, and follows a current trend of trying to give a physical explanation to the origin and nature of the gravitational force. It is enough to remember the contributions that consider it as a force of entropic origin.

This *gravitational entanglement*, whose important evolution over time will be addressed later, the measure of its intensity is the gravitational force due to the mutual attraction between the nucleons of two bodies. In such a way, body A perceives a *gravitational charge* N_B from body B and vice versa. And in view of (25), we can already say that it is a quantum coupling constant that plays a key role in entanglement. $\hat{G}$

Explaining the force of gravity using quantum-mechanical ideas such as quantum entanglement with scientific arguments may seem very forced and unscientific, given the evidence that all baryonic matter is attracted. But from the *Quantum-Gravitational Theory* we precisely intend to give a coherent answer to this evidence, why is matter attracted? If we look at similar phenomena in nature, such as the forces of attraction generated between bodies with opposite electric charges or magnetic fields created by materials with these properties, how can we reject a priori that baryonic matter, its nucleons, have a *gravitational charge*? Obviously this argument is more heuristic than scientific, but the relevant relationship of (25) does have a deep scientific significance.

Figure 6				
Gravitatory Study Silver-Gold				
Porton mass(Kg)	G(m ³ /Kg.s ²)	$\hat{G}$ (m ³ /eV.s ²)	E _{PGM} (Ev)	$\mathcal{E}$
1,672621925950E-27	6,67430000000000E-11	1,78470306952957E-46	6,2551472628667E+08	6,982984013595780E-29
Ag mass (Kg)		Au mass (Kg)		Distance (m)
3		4		1
Nucleons Ag (N _{ag})		Nucleons Au (N _{au})		Kg → eV
1,793591E+27		2,391455E+27		5,60958860300000E+35
Clasic-Newtonian Formulation (eV)			Quantum-Gravitaroy Formulation (eV)	
4,492809265560350E+26			4,492809266224940E+26	

Figure 7				
Gravitatory Study Sun-Jupiter				
Proton mass(Kg)	G(m ³ /Kg.s ²)	$\hat{G}$ (m ³ /eV.s ²)	E _{PGM} (Ev)	$\mathcal{E}$
1,672621925950E-27	6,67430000000000E-11	1,78470306952957E-46	6,2551472628667E+08	6,982984013595780E-29
Sun mass (Kg)		Jupiter mass Kg)		Distance Sun-Jupiter(m)
1,989100E+30		1,898700E+27		7,78412020000000E+11
Sun nucleons (Ns)		Jupiter nucleons (N _J)		Kg → eV
1,189211E+57		1,135164E+54		5,60958860300000E+35
Clasic-Newtonian Formulation (eV)			Quantum-Gravitaroy Formulation (eV)	
2,333622676989100E+59			2,333622677334300E+59	

Figures 6 and 7 show two studies considering only the mass of the proton, rather than the average mass of the nucleon. The comparison of the results obtained between classical theory and *quantum-gravitational theory* could not be more conclusive.

With both studies we have demonstrated the validity of the quantum-gravitational formulation for the gravitational force between two bodies. And it is reasonable to think that, if two apparently different formulations obtain the same results, there must be some relationship between the two. And indeed there is as shown below:

$$\begin{aligned}
 F_{G_{AB}} &= \frac{3}{2} \frac{N_A \cdot N_B}{d_{AB}^2} \hat{\mathfrak{E}} = \frac{3}{2} \frac{N_A \cdot N_B}{d_{AB}^2} \hat{G} \cdot (E_{PGM} \cdot E_{PGM}) \\
 &= \frac{3}{2} \frac{N_A \cdot N_B}{d_{AB}^2} \hat{G} \left(\frac{2}{3} E_{max} \right) \left(\frac{2}{3} E_{max} \right) = \frac{N_A \cdot N_B}{d_{AB}^2} \frac{2}{3} \hat{G} (M_{exp}) (M_{exp}) \\
 &= G \cdot \frac{1}{d_{AB}^2} N_A M_{exp} \cdot N_B M_{exp} = G \frac{M_A \cdot M_B}{d_{AB}^2} eV \cdot m \cdot s^{-2} \quad (26)
 \end{aligned}$$

As shown, both formulations are equivalent, but their big difference is that in the *quantum-gravitational formulation* the quantum origin of gravity is evident due to the *universal gravitational quantum* $\hat{\mathfrak{E}}$. Let us not forget that And although apparently the two are the same equation expressed in different terms, from the Newtonian equation it is not possible to obtain the quantum-gravitational equation, because the gravitational quantum. it is not a mere product of the quanta of the two bodies, but the gravitational entanglement of both. $E_{PGM} = \hbar\omega \cdot \hat{\mathfrak{E}}$

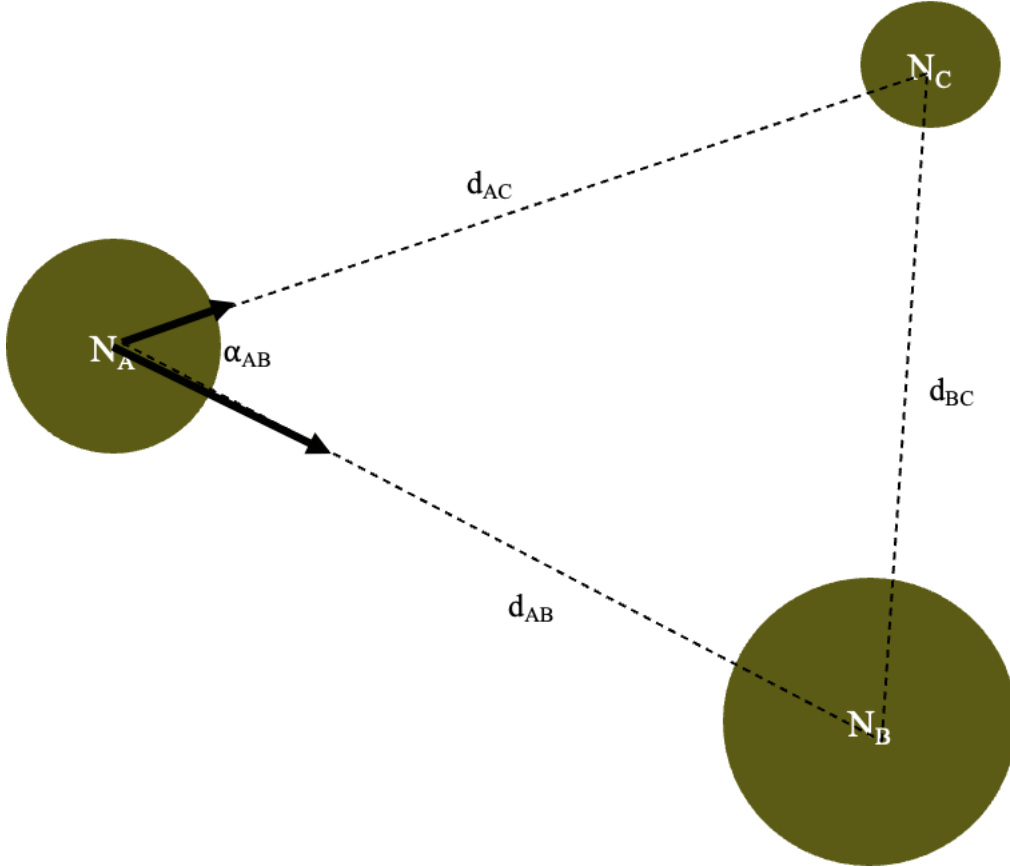
The conditions imposed on the environment are very restrictive but necessary, although they may seem arbitrary. It is about analyzing an ideal situation of two macroscopic bodies that lack history, and in a universe where the only baryonic matter is that provided by them. The necessity is imposed to isolate our laboratory of ideas from the gravitational contamination of our physical life as matter. To do otherwise would force us to go back to the early moments of our universe, just after hadronization, which would divert us from our current goal. However, its discussion and detailed reasoning will be addressed at the end of this chapter.

Finally, the gravitational entanglement shown by the relationship (25) requires a more detailed analysis and in a broader context where matter fills our universe, and considering its evolution over time. First, we will address a primary and instructive vector analysis and then we will perform a quantum-mechanical analysis of its temporal evolution.

II. Entangled Matter: Vector Analysis

Let be an ideal gravitational system consisting of three bodies A, B, and C at any instant t of its dynamical evolution

Figure 8: Quantum-Gravitatory net



The gravitational forces existing in our system will be those generated by the three bodies among themselves:

$$F_{AB} = \frac{3}{2} \cdot \frac{N_A \cdot N_B}{d_{AB}^2} \hat{\mathbb{C}}; F_{AC} = \frac{3}{2} \cdot \frac{N_A \cdot N_C}{d_{AC}^2} \hat{\mathbb{C}}; F_{BC} = \frac{3}{2} \cdot \frac{N_B \cdot N_C}{d_{BC}^2} \hat{\mathbb{C}} \quad (27)$$

The only force exerted on them is the gravitational force, there is no other matter around and we are not interested in their dynamic evolution, or if they are in gravitational equilibrium. We just want to know the resulting gravitational vector on A due to B and C.

If we place our coordinate system on the body A, as shown in Figure 8, the gravitational vectors of B and C will exert their gravitational effects on A dampened by the squares of the distances that separate them.

The resulting gravitational vector will be the vector sum of VB and VC :

$$\overrightarrow{V_{BC}} = \sqrt{|V_B|^2 + |V_C|^2 \pm 2 \cdot V_B \cdot V_C \cdot \cos \alpha_{AB}} \quad (28)$$

Or in its developed form

$$\overrightarrow{V_{BC}} = \widehat{\mathfrak{G}} \sqrt{\left| \frac{N_B}{d_{AB}^2} \right|^2 + \left| \frac{N_C}{d_{AC}^2} \right|^2 \pm 2 \cdot \frac{N_B \cdot N_C}{d_{AB}^2 d_{AC}^2} \cdot \cos \alpha_{AB}} \quad (29)$$

It shows that the resulting gravitational vector to which body A is subjected is proportional to the sum of the squares of the gravitational vectors of B and C, applied to A, plus/minus the ratio between the product of the gravitational vectors of B and C, and the product of the distances separating it from A.

Following the same reasoning for a system of n-bodies, we can arrive at a general expression:

$$\overrightarrow{V_R} = \widehat{\mathfrak{G}} \sqrt{\sum_{i=1}^n \left| \frac{N_i}{d_i^2} \right|^2 \pm \sum_{i=1, j=2}^n B_{ij}} \quad (30)$$

Obviously, the value of VR will be impossible to obtain if we want to consider all the matter in the universe, which in turn we do not know. We will denote, for simplicity, the modulus of the universal gravitational resultant over any point in space as $\overrightarrow{R}$. And now it will be:

$$\overrightarrow{V_R} = \widehat{\mathfrak{G}} \overrightarrow{R} \quad (31)$$

But we are not interested in the quantization of the resulting VR vector on a body, but in showing the relevant presence of the *universal gravitational quantum* $\widehat{\mathfrak{G}}$ as a common link to all baryonic matter.

And although the cosmological gravitational result cannot be obtained empirically, we can limit its first terms, which will be the ones that will locally define its value. $\overrightarrow{R}$

Vector analysis is exhausted at this point. Regardless of the complexity of the formulation (30), it has achieved its objective by showing that baryonic matter recognizes each other and remains gravitationally entangled by means of the *gravitational quantum* that it itself generates.

III. Entangled Matter: Quantum-Mechanical Analysis

From the combination of formulations (24) and (31) we obtain:

$$\overline{V_R} = \widehat{\mathcal{E}}\vec{R} = \hat{G} \hbar^2 \omega^2 \vec{R} \quad (32)$$

Where it represents the frequency of harmonic-quantum oscillation of the quarks in the nucleons and the gravitational effect of all the matter surrounding the observer. In this more detailed form we can subdivide it for analysis into two parts: the first three terms common to all baryonic matter represent their $\omega\vec{R}$ *gravitational entanglement*, while the last term represents the *gravitational charge* responsible for the observed effects.

If, as we are proposing, all matter is *gravitationally entangled* in the present moment, it also had to be so since its creation. It was in the process of *hadronization* that the gravitational entanglement and attraction of matter began. Then we have to place our analysis in those first instants of our universe, where the physics of quantum-mechanics was the prevailing one within it.

The history of the universe before the first second was quite chaotic, with an inflationary process and the continuous annihilation between matter and antimatter in the phenomenon known as *baryogenesis*. Therefore, we will be in the lepton era when the universe was only approximately 1 s old and both processes had ended, and the universe was in thermal equilibrium.

Its initial conditions could be summarized as follows:

1. Approximate temperature of 10¹⁰ °K and in thermal equilibrium.
2. A small universe with an expansion factor $a \gg ct$
3. Particle plasma: photons, protons, neutrons, electrons, and neutrinos.
4. Supposed low entropy.
5. Flat space-time.

These conditions define a small, hot, and dense universe. It should be noted that its real size is irrelevant to the study, although it is important to highlight its small volume compared to the current moment. Of all the particles in the primordial plasma, it is the protons and neutrons that actually contribute more than 95% to the density. Photons and neutrinos contribute practically nothing, and electrons account for a tiny part. The relevant fact is that all protons and neutrons were created during the process of hadronization, and from then until today it has remained practically constant. There is no known natural process that generates protons from quarks not contained in previous matter, a necessary condition for the conservation of baryonic number.

The condition of low entropy is imposed by the second law of thermodynamics. The logic of the law tells us that, if entropy always increases in the direction of time, the universe must have less entropy at its beginning than at the present time. Quantifying it in both situations is not an easy or necessary task at the moment. We must be satisfied with logical reasoning, but it will require strong nuances later.

The current estimated density of baryonic matter with respect to the critical density is 0.044. As the estimated critical density is $9.47 \times 10^{-27} \Omega_B \Omega_C \text{ Kg/m}^3$, the density of baryonic matter is $4.1668 \times 10^{-28} \text{ Kg/m}^3$ for an estimated volume of observable universe of about 43,500 106 light-years. The baryonic density corresponding to a universe of 4 light-years is $4.5314 \times 10^{-18} \text{ Kg/m}^3$, which is much higher than that estimated for that era of the universe. This density corresponds to approximately 2.7×10^{18} protons/cm³. The accelerated expansion may have

contributed to a sharp decrease in the density of matter, but even so in that first second we can idealize our universe as a ball of radiation and matter in the form of protons and neutrons.

And in this idealized context of an expanding volume populated by protons and neutrons (the rest of the particles do not significantly influence) with an isotropic and uniform distribution, we can disregard the term B_{ij} from equation (30), and since $N_i = 1$, we obtain that for a nucleon in located at its center the baryonic attraction exerted by the rest is:

$$\overrightarrow{V_R} = \hat{\mathbb{E}} \sqrt{\sum_{i=1}^N \left| \frac{1}{d_i^2} \right|^2} \quad (33)$$

This extreme idealization is another temporal perspective of (32), where now $\mathbf{R}$ does not represent the grouped matter, but each nucleon individually, a step prior to the entire subsequent gravitational process. Baryonic matter performs an exchange of quantum information simultaneous to its own creation, sharing its *gravitational charge* indefinitely. This exchange of quantum information can be assimilated to the *exchange interaction* described for magnetism by the Heitler-London theory.

Sougato Bose et al [18] describe the lowest level of *gravitational entanglement* between two quantum-harmonic oscillators as:

$$\Delta\phi = \frac{2Gm^2}{d^3} x_A x_B \quad (34)$$

Its equivalent in the GCT would be:

$$\Delta\phi = 3\hat{\mathbb{E}} \frac{N_A N_B}{d^3} x_A x_B = 3\hat{G} \hbar^2 \omega^2 \frac{N_A N_B}{d^3} x_A x_B \quad (35)$$

Equation (15) is the third term in a series obtained from two quantum-harmonic oscillators of equal masses. Our reasoning is that this term is equally valid for unequal masses. In (35) the constant plays the role of $(N_A \neq N_B)\hat{G}a$ *gravitational entanglement constant* that we already intuited in (24), thus acquiring a profound physical meaning.

The physical picture we are trying to describe is that of a small but expanding universe, with a very high density of protons and neutrons endowed with great kinetic energy, carriers of *gravitational charges* that produce their global entanglement. It is the description of a quantum universe that gravity later also made classical, although it has not ceased to be quantum. The gravitational force is quantum, as shown by *gravitational entanglement*, but its effects observed by classical entities are obviously classical, and therefore are perceived by our senses.

The physical description of the temporal evolution from that moment 0 to the present is a scientific challenge that has not yet been resolved. Evolving from a boiling plasma of protons and neutrons to mass structures such as stars and black holes is impossible without a primary attraction of the fundamental constituents of matter, regardless of whether other physical phenomena contributed. Let's not forget the electrical repulsion between protons itself, which is on the order of 36 times greater than their gravitational attraction.

The process of atomic formation brought about electrical neutrality, eliminated the consequent repulsion, and contributed considerably to gravitational evolution, but it could not have been enough to create such enormous masses in such a short space of time, as the Webb telescope is showing us [23][24]. If we add to this the fifth initial condition of a flat universe, since the homogeneous and isotropic plasma of protons and neutrons could not distort the

geometry of space-time, we find ourselves in a utopian situation of immense and diluted HII clouds, which on their own would never have collapsed in a continuously expanding universe. Despite the rapid cooling of the universe, the weak *gravitational entanglement* was not enough to cause the collapse of matter as we know it today. There had to be some kind of space-time instabilities for that universe to stop being so homogeneous and uniform, and to trigger all the great gravitational evolution of matter.

There are currently three main hypotheses in this line of argument: *Dark energy*; *Dark matter* and *Primordial Black Holes* (NPOs). Our ideas are in support of the PNAs, as we will argue and develop in depth in the chapter dedicated to the *quantum-relativistic formulation*.

Quantum-Relativistic Formulation or of matter as energy

The CDM standard cosmological model tries to respond to the apparent lack of baryonic matter, based on observations in the optics and dynamics of the outermost stars of galaxies, introducing *cold dark matter* among its parameters. The roots of the Standard Model are in turn based on the FLRW model, which assumes the universe as a perfect fluid at cosmological scales, where galaxies are the elements of the fluid with a homogeneous and isotropic density of matter. This idealization carries some risks. The first is to consider all galaxies as homogeneous masses when observations provide us with important differences, and the second and most relevant is that it does not take into account gravitational effects.

$$G_{\alpha\beta} = \frac{8\pi G}{c^4} T^{\alpha\beta} \quad (36)$$

At the origin of all cosmological models is the equation of the *General Theory of Relativity*, where it is essential to define the tensor of matter $T^{\alpha\beta}$; in order to obtain Einstein's tensor and the metric tensor of space-time, $G_{\alpha\beta}g_{\mu\nu}$. Consequently, the concept of matter or mass is the key to describing what kind of space-time generates or causes. Based on the previous chapters where we exposed the foundations of the *quantum-gravitational theory*, we address in this one a conceptual turn of the **GRT** and its cosmological model, replacing mass with its equivalent *gravitational energy* and the consequent modification of the right side of Einstein's relativistic equation.

The exhibition is divided into three parts:

1. Bases for a quantum-gravitational cosmological model: A study of the energetic evolution of our universe is carried out, considering it as a closed system and applying the laws of thermodynamics.
2. The gravitational Hamiltonian: The gravitational Hamiltonian of the universe is defined as including all baryonic matter and its entanglement relationships. Deducing that matter cannot guarantee the conservation of the energy of the universe.
3. Quantum-gravitational relativistic equation: The substitution of the energy-momentum tensor of matter by the tensor of gravitational energy in the equation of General Relativity, given the previous verification of the equivalence between baryonic matter and gravitational energy.

I. Bases for a Quantum-Gravitational Cosmological Model

The consideration of the universe as a closed system in its classical sense has strong cosmological implications that are not the subject of this article but that are the basis of all its subsequent development, applying it in its most restrictive and strong sense as an absolute whole at any moment in its history.

The model uses these four physical pillars:

1. Laws of Thermodynamics.
2. The space-time defined by the **TGR**.
3. Quantum-mechanical theory.
4. Baryonic matter and gravitational energy are equivalent.

The first three pillars are already a collection of the scientific community, while the last will be the main object of this article.

We are especially interested in the first law of thermodynamics of the conservation of energy throughout the history of the universe, and therefore we will make a comparison between the energies of a primordial moment and the present moment.

The initial conditions when the universe was 1 s old, at the end of the inflationary era, hadronization and baryogenesis could be summarized as follows:

1. Approximate temperature of 10¹⁰ °K and in thermal equilibrium.
2. A small universe with an expansion factor $a \gg ct$
3. Particle plasma: photons, protons, neutrons, electrons, and neutrinos.
4. Low entropy.
5. Flat space-time.

These conditions define a small, hot, and dense universe. Its parameters for this time are: a total energy $Eu(t_0)$; Baryonic nu particles (protons and neutrons); initial volume $Vu(t_0)$; temperature $Tu(t_0)$; entropy $Su(t_0)$ and finally by an expansion factor $au(t_0)$.

The energy $Eu(t_0)$ is the sum of the following energies, all of which are positive.

$$E_u(t_0) = E_{\gamma_0} + E_{\mu} + E_{C_0} + E_{P_0} + E_r + E_X + E_{BB_0} + E_{G_0} \quad (37).$$

E_{γ_0} it is the energy due to photonic radiation; it is the energy due to the rest mass of all particles; it is the kinetic energy of all of them; it is the residual energy mainly due to electrons and neutrinos; it includes possible potential energies, excluding gravitational energy; $E_{\mu}E_{C_0}E_rE_{P_0}EX$ represents the energy associated with *the background X-radiation*, due to the braking between electrons and protons, known as *bremsssthrallung*; it is the energy left over from the Big Bang by which the universe continues to expand and finally encompasses all gravitational energies. $E_{BB_0}E_{G_0}$

In the present tense tI , the verified energies are detailed below:

$$E_u(t_1) = E_{\gamma_1} + E_{\mu} + E_{C_1} + E_{P_1} + E_{BB_1} + E_M + E_{G_1} \quad (38)$$

The initial radiation energy has practically disappeared as matter prevails over radiation. has remained practically constant. it must have diminished by the expansion itself. we can consider it constant, although we sense its value to be negligible. $E_{\gamma_1}E_{\mu}E_{BB_1}E_{P_1}E_r$ it will have decreased appreciably as a result of atomic formation. EX , although it could be associated with current *background X-radiation* such as *bremsssthrallung*, its value has to be significantly lower. EM encompasses the energies associated with the radiation of matter due to their grouping: extragalactic light background (EBL), background X-ray radiation as a possible origin in quasars and gamma-ray bursts. The quantitative assessment of kinetic energies requires a more detailed analysis in their respective times. E_{C_1} y E_{C_0}

The universe described in t_0 meets the conditions to be able to apply the *theorem of equipartition to it*, being able to define its kinetic energy as a function of its temperature by:

$$E_{C_0} = \frac{3}{2}NT_u \quad (39)$$

where NT includes photons, electrons, baryons, and neutrinos. We avoid applying the *virial theorem* for two fundamental reasons: the strong expansion and exclusion of gravitational potential energy, in addition to the very possible presence of non-conservative forces.

If we take our present time with an estimated age of the universe of 13.8 billion years and a temperature of 2.7 °K, the resulting cooling rate is 7.25 °K/year. Obviously it does not respond to its thermal history, as it cooled much more quickly in its early years. But it does respond to the hypothesis that its cooling was not due to the growth of its volume, then if it had been so it would be correct and there is no evidence that the expansion factor was greater at the beginning (after the inflationary era), but the latest observations indicate the opposite.

The sharp drop in temperatures in the early epoch of the universe becomes a decisive factor in its energy evolution. We have to momentarily abandon the analysis of kinetic energy in our present time, to focus on an intermediate epoch when the universe was 340,000 years old, when it began to become transparent by emitting the E_{C_1} cosmic microwave background (MCF).

We can continue to apply the *equipartition theorem* and then the kinetic energy for this time t' will be:

$$E'_{C_1} = \frac{3}{2} N_T T'_u \quad (40)$$

The universe underwent a drastic cooling in its first 340,000 years, going from the first minute with an approximate temperature of more than 1010 °K to about 4,000 °K. This resulted in a decrease in kinetic energy 25×10^6 from the initial kinetic energy with the total number of NT particles constant.

The cause of this very strong decline is currently attributed to the great expansion that our universe experienced at that time. We differ from that interpretation. Temperature is a measure of the internal energy of the particles contained in a system and is fundamentally kinetic. If the system is closed in its strictest sense as we are considering it, and if the number of particles existing at the instant t_0 is constant at all times, and in thermal equilibrium, its expansion cannot lead to a decrease in temperature. The new volume is due to the expansion of the space without any energy input. There is no physical reason for the temperature to decrease, since the kinetic energy has not been able to vary by the expansion of volume and the radiated thermal energy is null as a whole because all the particles are in thermal equilibrium, consequently, the new volume remains at the same temperature. Obviously the energy density does decrease with volume, but the energy must remain unchanged.

The intense electromagnetic radiation that must have existed at this stage, mainly due to photonic radiation, may have decayed, but it was compensated by the transfer of energy to the rest of the particles, increasing their kinetic energy. In any case, its possible decrease seems clearly insufficient to compensate for the estimated loss of energy.

To consider the universe as a closed system, which encompasses everything, without limits or borders, in other words, infinite at all times, may be speculative and at the same time a plausible hypothesis. Therefore to think that it can radiate energy out of it is simply absurd and for that reason the Stefan-Boltzmann law of blackbody radiation cannot be applied to it. Likewise, the universe has been expanding at superluminal speeds, so the particle plasma has not been able to exert pressure on any part of the universe. There are therefore other causes that generated the drop in temperature.

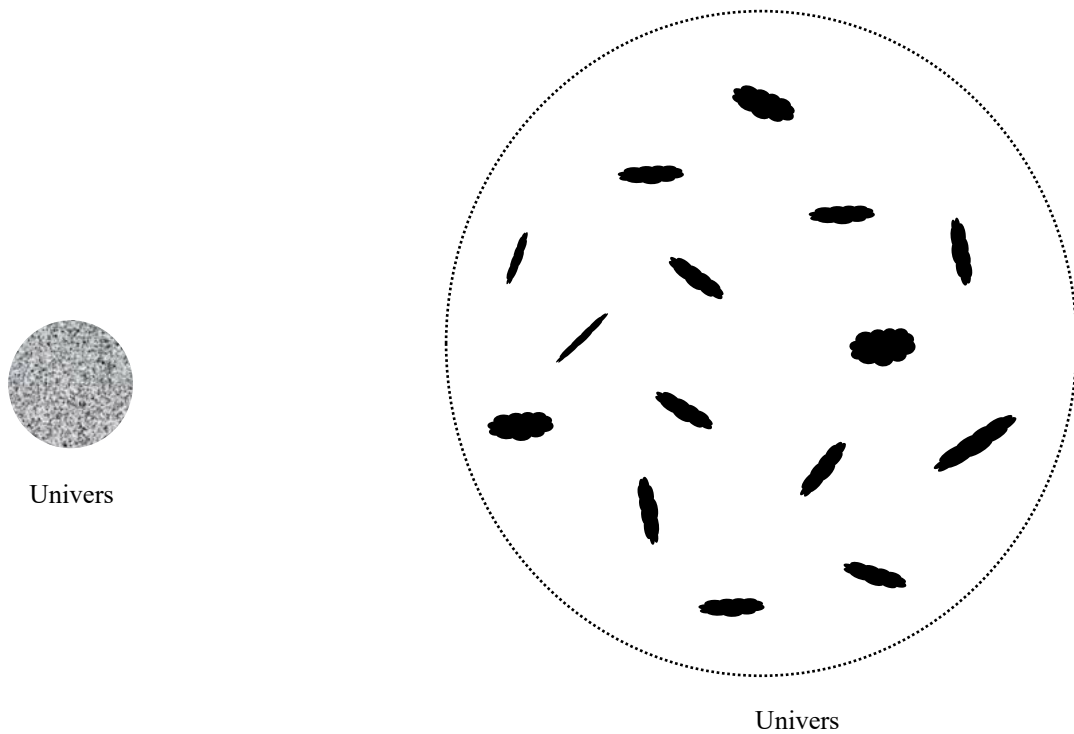


Figure 9

The figure schematically represents our primordial universe t_0 and the current universe t_1 . The only two visual observables are the size and distribution of matter, and two thermodynamic principles that must be met: energy has been conserved and entropy has increased.

If we return to the kinetic energy of our present time, we cannot assess it by the theorem of equipartition, since we find bodies of different sizes grouped in galaxies that are also very variable. But we can measure the kinetic energy of our sun and compare it with the energy that all its component particles would generate at time $E_{C_1} t_0$. The kinetic energy generated by our Sun by its translational motion is approximately 3.9108×10^{55} eV (Mass = 1.9891×10^{30} Kg; Orbital velocity = 2.51 Km/s), assuming that it is only composed of protons (1.18921×10^{57}) at the temperature of 1010 °K we obtain an energy of $1.53717283 \times 10^{64}$ eV. This shows us that the grouping of matter also meant a reduction in energy that is not compensated by its own motion. The energy due to rotational motion has no nature related to gravitational energy and could be shown to have been constant throughout the history of the universe.

In conclusion, the kinetic energy and the contribution of $E_{C_1} \ll E_{C_0} EM$ energy to the total energy of the universe can be considered negligible, given its instability and variability, both in its light and thermal aspects.

All energy contributions to Eu have decreased considerably, or have remained constant as is the case with, could only guarantee the conservation of energy of the universe. $EE_\mu E_{GG}$ represents all gravitational energy whose origin is baryonic matter. We therefore need to find the expression of the EG Hamiltonian that can be used for any moment in the history of our universe and thus be able to assess its contribution to the conservation of the energy Eu .

II. The gravitational Hamiltonian

In all the evolutionary energy analysis of the previous section, gravitational energy has been practically absent. The obvious conclusion that it presupposes the non-conservation of the total energy of the universe and that only the gravitational energy $E_u(t_0) \gg E_u(t_1)EG$ can guarantee it. For this reason, we will address its study below.

From the *Quantum-Mechanical Formulation* we know that the equivalent of mass in gravitational energy is:

$$M = N \cdot E_{max} = \frac{3}{2} N \cdot E_{PGM} \quad (41)$$

This formulation can be transformed by multiplying and dividing by N , to transform it into the gravitational Hamiltonian form of an isolated body of common baryonic matter: $\hat{G} \cdot E_{PGM}$

$$\mathcal{H}_{CO} = \frac{3 N^2 \hat{\mathfrak{E}}}{2 N \mathfrak{E}} = \frac{3}{2} \frac{E_{GEN}}{E_{EMI}} \quad (42)$$

Every body composed of more than one nucleon is energetically defined as the relationship between the gravitational energy of entanglement that holds it together and the energy it emits as matter. Thus mass can be expressed as a relationship between internal entanglement energies and external entanglement energy.

The fundamental relationship of *quantum-gravitational entanglement* is:

$$\vec{\mathfrak{E}} \cdot \vec{\mathfrak{E}} = \hat{G} E_{PGM} \cdot \hat{G} E_{PGM} \lesssim \hat{G} (E_{PGM} \cdot E_{PGM}) = \hat{\mathfrak{E}} \quad (43)$$

And it expresses at the quantum level the *gravitational entanglement* between baryonic matter. This same relationship can also be expressed in classical terms of energy, as the sum of the energies emitted individually by each body that will be transformed into the energy of entanglement.

$$\mathfrak{E} + \mathfrak{E} + E_{EN} = \hat{\mathfrak{E}}$$

$$2\hat{G}E_{PGM} + E_{EN} = \hat{G} E_{PGM}^2 \quad (44)$$

The above relationship clearly shows the need to introduce a new EEN term to ensure energy conservation.

$$E_{EN} = \hat{G} E_{PGM} (E_{PGM} - 2) \approx \hat{G} E_{PGM}^2 = \hat{\mathfrak{E}} \quad (45) \quad \text{Whereas } E_{PGM} \gg \gg 2$$

EEN expresses the energy generated by the quantum-gravitational entanglement whose unit value is approximately the *universal gravitational quantum itself*. $\hat{\mathfrak{E}}$ This means that *gravitational entanglement* is a continuous source of energy and quantum exchange between matter. Therefore, the *universal gravitational quantum* $\hat{\mathfrak{E}}$ has a double physical value: it expresses the quantum-gravitational entanglement between matter and the gravitational energy that generates that entanglement. The consideration of the *gravitational quantum* $\mathfrak{E}$ as energy is not arbitrary, since it is the product of E_{PGM} by the quantum gravitational constant, whose units are conventional and inherited from $\hat{G}$.

Gravitational entanglement is the physical manifestation of matter's attractive recognition of each other, and it can be observed in two different forms: isolated matter and distant matter. The first is a consequence of their gravitational effects over time forming aggregate bodies such as stars and planets, and the second deals with the gravitational effects that they exert mutually between them. And if the grouped matter is itself gravitational energy, it is so for the sole reason that previously that same matter has emitted gravitational energy in accordance with (43) and earlier. There is therefore a constant exchange of energy between matter through space-time. The Hamiltonian that describes the energetic interaction of gravitational entanglement between two bodies of equal mass at low perturbations is defined by [18]:

$$\mathcal{H}_{EN} = 2 \frac{Gm^2}{d^3} \delta \hat{x}_A \cdot \delta \hat{x}_B \quad (46)$$

Multiplying and dividing by G, remembering that; and replacing: $G = \frac{2}{3} \hat{G} Gm = N\mathfrak{E}$,

$$\mathcal{H}_{EN} = 3 \frac{N^2 \mathfrak{E}^2}{d^3 \hat{G}} \cdot \delta \hat{x}_A \cdot \delta \hat{x}_B \quad (47)$$

Its last fraction carries a deep physical meaning.

$$\frac{\mathfrak{E}^2}{\hat{G}} = \frac{\mathfrak{E}\mathfrak{E}}{\hat{G}} = \frac{\hat{G}E_{PGM} \cdot \hat{G}E_{PGM}}{\hat{G}} = \frac{\hat{G}^2(E_{PGM} \cdot E_{PGM})}{\hat{G}} = \hat{G}(E_{PGM} \cdot E_{PGM}) = \mathfrak{E} \quad (48)$$

Finally:

$$\mathcal{H}_{EN} = 3 \frac{N^2}{d^3} \mathfrak{E} \cdot \delta \hat{x}_A \cdot \delta \hat{x}_B \quad (49)$$

This is the Hamiltonian expression of gravitational entanglement in terms of the **TCG**. In the case of bodies of different masses, it would take the form of:

$$\mathcal{H}_{EN} = 3 \frac{N_1 N_2}{d^3} \mathfrak{E} \cdot \delta \hat{x}_A \cdot \delta \hat{x}_B \quad (50)$$

The study of the Hamiltonian of (50) between distant bodies is much more complex in terms of its quantification and not so much in terms of its mathematical development. One of the fundamental principles of GCT is that every body of baryonic matter is gravitationally entangled with the rest of the bodies in the universe. This means that all the bodies in the universe are mutually entangled two by two. It is therefore a combination of all of them taken two by two without repetition. Its mathematical expression would be:

$$C_{SR} = \frac{n!}{x!(n-x)!} \quad (51)$$

Quantization is only possible in close environments where it is known *and* prior idealization. Combining (50) and (51) we can express the Hamiltonian of distance entanglement as:

$$\mathcal{H}_{EN} = 3\mathfrak{E} \sum_{ij}^n \mathbb{C}_n^2 \frac{N_i N_j}{d_{ij}^3} \quad (52)$$

$\mathbb{C}_n^2$ It represents all possible combinations between every two bodies.

As a quantitative reference, the energy of entanglement with our satellite is 5.78×10^{47} eV, eleven orders lower than the energy of the Moon as a mass (4.1225×10^{58} eV).

The latest contribution to the total Hamiltonian of the gravitational energy EG is the special case of *black holes* as the maximum expression of the clustered matter. Jacob D. Bekenstein [25] in 1972 formulated the *Second Generalized Law of Thermodynamics* in which he states that the sum of common entropy and the entropy of black holes never decreases,

$$\delta(S_C + S_{BH}) > 0 \quad (53)$$

It is a more detailed way of expressing the *second law of thermodynamics*, since it introduces an important differentiation between common entropy and entropy of *black holes*, clearly understanding that what is not entropy of *black holes* is common entropy. Their evolution over time is a challenge in current physics, since the formation of black holes themselves is a matter of scientific discussion and analysis.

Later Stephen Hawking [26] proposed the formulation to measure the entropy of a *black hole*:

$$S_{BH} = \frac{1}{4} \frac{k_B c^3}{G \hbar} A_K \quad (54)$$

In it, its entropy is related to its area with a *Kerr metric*, which is one of the most appropriate solutions of *the equations of general relativity* for the study of *black holes*. In turn, the area of its *event horizon* A is given by:

$$A_K = \frac{8\pi G^2}{c^4} m \left(m + \sqrt{m^2 - a^2} \right) \quad (55)$$

where am is its angular momentum and if $a = 0$, then it is reduced to the *Schwarzschild metric*.

$$A_K = \frac{16\pi G^2}{c^4} m^2 \quad (56)$$

Combining (54) and (56) we get:

$$S_{BH} = 4\pi \frac{k_B G}{c \hbar} m^2 \quad (57)$$

$G = \frac{2}{3} \hat{G} GM = N \mathbb{E}$ This is the entropy of a mass-dependent static, charge-neutral black hole. Multiplying and dividing by G and remembering that; and substituting in accordance with (48):

$$S_{BH} = 6 \frac{\pi k_B}{c \hbar} N^2 \frac{\mathbb{E}^2}{\hat{G}} \quad (58)$$

And subsequently:

$$S_{BH} = 6 \frac{\pi k_B}{c \hbar} N^2 \hat{\mathbb{E}} \quad (59)$$

This is the expression of the entropy of a *black hole* in terms of *quantum-gravitational theory*. The entropy of the clustered matter is directly related to the energy generated in its own clustering represented by $N^2\mathfrak{E}$. But his contribution to the gravitational Hamiltonian is the relationship between the internal entanglement energy and the emitted energy, according to (42), as the matter that is, since (59) defines only the gravitational energy entangled inside the *black hole*, and then it becomes:

$$\mathcal{H}_{AN} = 6 \frac{\pi k_B}{c\hbar} \frac{N^2\mathfrak{E}}{N\mathfrak{E}} = 6 \frac{\pi k_B}{c\hbar} \frac{E_{GEN}}{E_{EMI}} \quad (60)$$

Now we are in a position to define the complete Hamiltonian of gravitational energy. By joining (42), (52) and (60) we get:

$$\mathcal{H}_{GR} = \mathcal{H}_{CO} + \mathcal{H}_{AN} + \mathcal{H}_{EN} = \frac{3}{2} \sum_i^n \frac{N_i^2\mathfrak{E}}{N_i\mathfrak{E}} + 6 \frac{\pi k_B}{c\hbar} \sum_j^m \frac{N_j^2\mathfrak{E}}{N_j\mathfrak{E}} + 3\mathfrak{E} \sum_{i,j}^{n+m} \mathbb{C}_n^2 \frac{N_{i,j}N_{i,j}}{d_{i,j}^3} \quad (61)$$

The first two terms represent the energy due to the clumped matter in common and black holes, and the last term measures the exchange of gravitational energy between all the matter included in the first two

$\mathcal{H}_{CO} + \mathcal{H}_{AN} + \mathcal{H}_{EN}$) Of the three components of the Hamiltonian, two are local () and one cosmological (. This is pure non-visible energy that is very present in environments with a high concentration of matter such as galaxies and especially their galactic centers. Despite the enormous complexity of its quantification, we can try to make an approximation. Nothing is closer and better known than our own galaxy to be able to assess it correctly in comparison with the rest of the energies.

The estimated mass of the Milky Way is approximately 1.28×10^{12} solar masses with a population of about 2×10^{11} stars. Our idealization will focus on its bulge accepting an approximate size of 16,000 light-years and a population of stars of 2×10^{10} solar masses. If in this idealized model we consider that all stars are identical to our Sun, the unrepeated combinations between every two solar stars in the bulge amount to approximately 1.999×10^{20} . The mass of our black hole Sagittarius A* is established at 4×10^6 solar masses. With these data we obtain the following results:

$$\mathcal{H}_{CO(1)} = 3\mathfrak{E} \frac{1}{2\mathfrak{E}} \sum_i^n N_i = \frac{3\mathfrak{E}}{2\mathfrak{E}} \cdot 1,28 \times 10^{12} \cdot 1,18921 \times 10^{57} = 1,42 \times 10^{78} \text{ eV}$$

$$\mathcal{H}_{CO(2)} = 3\mathfrak{E} \frac{1}{2\mathfrak{E}} \sum_i^n N_i = \frac{3\mathfrak{E}}{2\mathfrak{E}} \cdot 2 \times 10^{11} \cdot 1,18921 \times 10^{57} = 2,31 \times 10^{76} \text{ eV} \quad (62)$$

$$\mathcal{H}_{AN} = 6 \frac{\pi k_B}{c\hbar} \frac{N_k^2\mathfrak{E}}{N_k\mathfrak{E}} = 6 \frac{\pi k_B}{c\hbar} \frac{\mathfrak{E}}{\mathfrak{E}} \cdot (4 \times 10^6 \cdot 1,18921 \times 10^{57}) = 2,449 \times 10^{76} \text{ eV}$$

$\mathcal{H}_{CO(1)}$ it represents the estimated energy of the Milky Way that includes dark matter, while it is the classical energy due only to its idealized population of stars. In turn, it represents the energy provided by Sagittarius A*. $\mathcal{H}_{CO(2)} + \mathcal{H}_{AN}$

$$\mathcal{H}_{EN(Bulbo)} = 3\mathfrak{E} \mathbb{C}_n^2 \frac{N_j^2}{d_j^3} = 3\mathfrak{E} \cdot 1,999 \times 10^{20} \cdot \frac{(1,18921 \times 10^{57})^2}{A_d} \approx \frac{6 \times 10^{106}}{A_d} \text{ eV} \quad (63)$$

The value of the full Hamiltonian of the bulb is of enormous difficulty due to the distance attenuation factor ($\mathcal{H}_{EN}d^3$), applicable to each combination of its gravitational entanglement.

The energy associated with the Milky Way deduced from the motion of its stars farthest from the bulge is 30% greater than the sum of the energies associated with ordinary matter and black holes. The current Λ CDM model proposes that this non-visible matter is *cold dark matter* with numerous observations that fit its predictions, among which we highlight the recent collaboration of SPT-3G D1 [27]. Our proposal is that the energy of gravitational entanglement together with the galactic gas make up that non-visible matter, but for this this Ad attenuation $\mathcal{H}_{EN}$ should not be approximately of an order greater than 28. What does seem evident is that both theories, although exclusive, propose the existence of matter or its equivalent in non-visible energy and need definitive proof: for the first to detect some of the particles proposed for *dark matter*, and for the second to verify observationally the *gravitational quantum* $\mathbb{G}$.

The cosmological scope of is much broader, encompassing the entire universe. Its physical nature is the manifestation of the entanglement of baryonic matter, and as such it is also exercised and manifested between the galaxies that make up a large structure, thus between each galaxy there are gravitational channels through which matter is entangled. The set of all these channels whose expression is the Hamiltonian expression of distant entangled matter could be the so-called $\mathcal{H}_{EN}^{cosmic}$ web. [28][29]

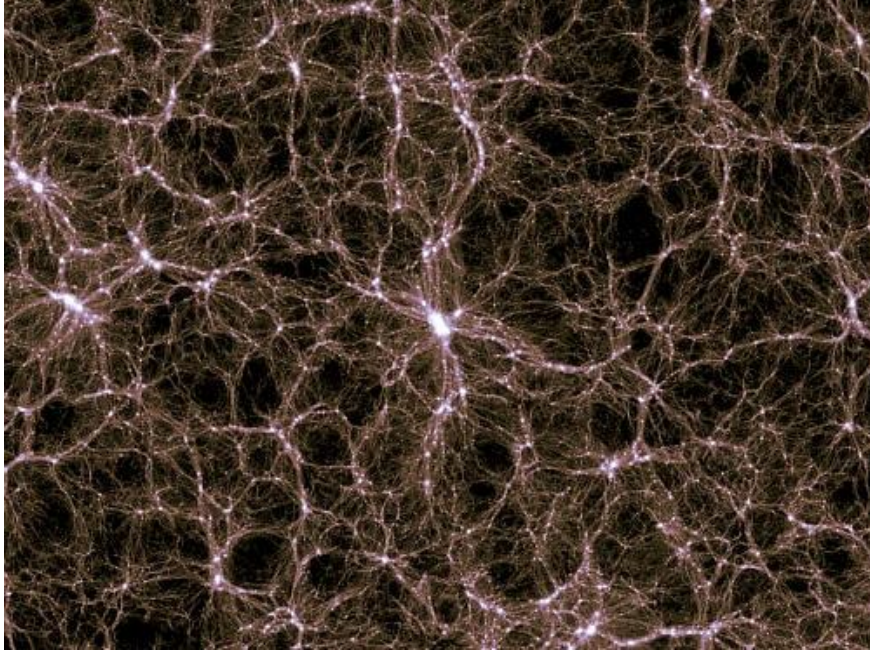


Image from the Sloan Digital Sky Survey III covering 650 million light-years and containing 1.2 million galaxies [30].

Figure 10

$\mathcal{H}_{EN}$ One last point. The formulation of (46) that we have used so far should be modified to be able to use it on cosmic scales. Let us not forget that its origin is only valid for small perturbations or equivalently for flat Minkowski spacetimes, and it is precisely not the spacetime that can be expected in galactic centers.

The sense in which we should reformulate or adapt it to be compatible with a curved spacetime exceeds our current knowledge, and we leave it open to future study. On the other hand, it is

reasonable to argue that the gravitational energy used in entanglement should be independent of distance, but not force, since it is an energy present throughout the exchange zone.

Having defined the *gravitational Hamiltonian* with its three components, we must verify whether it guarantees the conservation of energy at time $E_{G_1} t_l$. This is a sharp increase over , and in turn has to be synchronized with the temperature-dependent decrease in kinetic energy. The evolution over time of the E_{G_0} *gravitational Hamiltonian* is therefore key to understanding the nature of gravitational energy.

Assuming initially the absence of *black holes* at t_0 , the Hamiltonian takes the following form:

$$\mathcal{H}_{GR}(t_0) = \frac{3}{2} \mathbb{E} N + 3 \mathbb{E} \sum_i^N \mathbb{C}_N^2 \frac{1}{d^3} = \frac{3}{2} E_{PGM} N + 3 \mathbb{E} \sum_i^N \mathbb{C}_N^2 \frac{1}{d^3} \quad (64)$$

Since there are only N individual nucleons, the total gravitational energy is the sum of their common energy due to their own mass plus the energy of gravitational entanglement between each two.

The next and fundamental stage was nucleosynthesis, which was the first step in the long process of grouping matter. Now the Hamiltonian is:

$$\mathcal{H}_{GR}(t_0) = \frac{3}{2} \mathbb{E} \sum_1^n N_i + 3 \mathbb{E} \sum_{ij}^n \mathbb{C}_n^2 \frac{N_i N_j}{d_{ij}^3} \quad i \neq j \quad (65)$$

We continue to assume that black holes do not exist yet. Common matter is made up of hydrogen and helium nuclei, constituting the first link of the grouped matter. Nothing fundamental has changed from an energetic point of view, except that baryonic matter begins to clump together.

However, and contrary to what might be intuited, the sum of both terms not only does not remain constant over time, but decreases slightly with the grouping of matter. All mathematical calculations with varying degrees of clustering of matter and without black holes show that the sum of the Hamiltonians is not constant, but decreases slightly at the rate of clustering of matter. This is because it is constant because N is constant $\mathcal{H}_{CO}$ y $\mathcal{H}_{EN} \mathcal{H}_{CO}$ and will decrease at the rate of reduction of possible combinations as matter is grouped. This leads us to the fact that the Hamiltonian of $\mathcal{H}_{EN}$ *black holes*, $\mathcal{H}_{AN}$, has had to undergo a very strong increase to compensate for the decrease in the energy of the universe. There are still many unknowns about the origin and nature of black holes, but we are interested in the role they must have played in maintaining the conservation of energy in the early universe.

Let us imagine our universe as an ideal closed system, with no possibility of radiation to the outside, formed by a plasma of only N protons, like the one in Figure 11.A, with initial volume V_0 and temperature T_0 . The average energy of its kinetic and potential energies is $N.T_0$ according to the *virial theorem*, the energy corresponding to its E_{C0} masses, the energy associated with its distant gravitational relations E_{EN0} and an initial energy E_{EX0} that feeds its expansion. The absence of black holes at t_0 is assumed.



Figure A

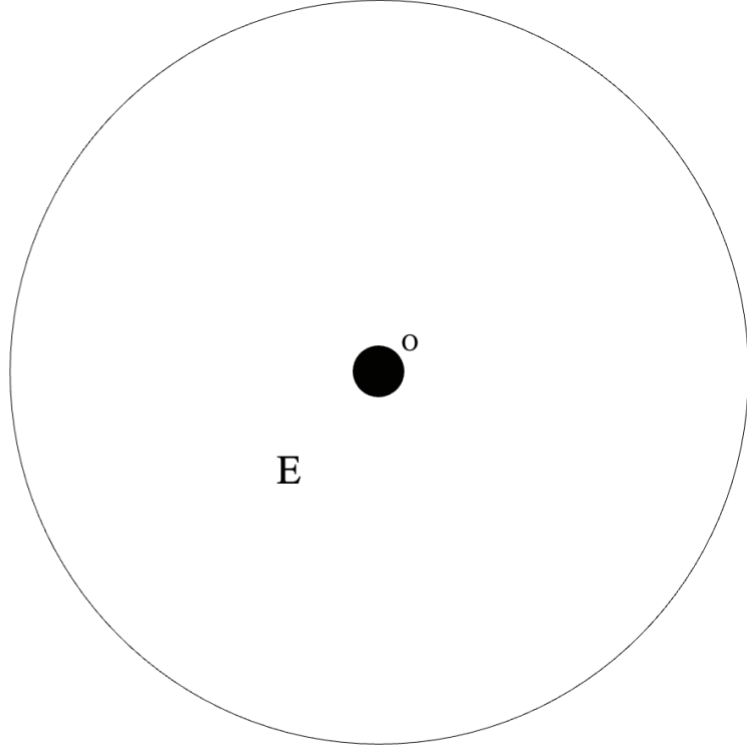


Figure B

Figure 11

After a certain time t_l , its comobile volume is now V_l , its temperature T_l , all the N protons are grouped at its center forming a *black hole* and the energy of its masses E_{Cl} , as shown in Figure 11.B.

The following relationships between the variables are verified in both times:

$$V_1 \gg V_0; T_1 \ll T_0; NT_1 \ll NT_0; E_{EN1} \ll E_{EN0}; E_{EX1} \ll E_{EX0}; E_{EN1} = 0; \\ E_{C0} = E_{C1} \quad (66)$$

At all times the total energy of the system must be constant: $E_u(t_0) = E_u(t_1)$ (67)

However, equality does not hold, since. The $E_u(t_0) > E_u(t_1)$ (68). E_{EN1} energy has to be zero since all the mass is concentrated in a single body. The energies due to their masses E_{C0} and E_{C1} could not vary since this would imply the non-constancy of the baryonic number N . The average NT_l energy has decreased proportionally to its temperature.

$$E_u(t_0) = NT_0 + E_{C0} + E_{EN0}; E_u(t_1) = NT_1 + E_{C1} + E_G \quad (69)$$

There are two possible answers: either the model is not real or in Figure 11.B there is gravitational energy that we do not appreciate. Whether it is a real model or not may be somewhat speculative, but it raises one of the cosmological hypotheses at stake regarding the future of our universe: the *Big Crunch*. It is enough for us that it is valid, even if it is far from the current theory. The second answer leads us to the fact that gravitational energy may be concentrated in *black hole* O, distributed in space E or in both.

The energy emitted as an isolated grouped mass is $N\mathfrak{E}$. If the temperature, as we have seen, has decreased by 25×10^6 degrees, and since the mass in O is isolated mass, we have to consider only the energy emitted $\mathfrak{E}$, which is of the order of 10^{-37} . It is therefore impossible for it to provide sufficient

compensatory energy independent of the value of N . E_G is the representation of the gravitational Hamiltonian of (26), which is reduced to: $\mathcal{H}_{GR}$

$$\mathcal{H}_{GR} = \mathcal{H}_{AN} = 6 \frac{\pi k_B}{c\hbar} \frac{\mathbb{E}}{\mathbb{E}} N \quad (70)$$

Considering that the gravitational energy of a black hole is about 8,231 times greater than the energy of ordinary matter, we find that it is still totally insufficient to guarantee the conservation of energy of the model. This exercise in extreme idealization shows that the *gravitational Hamiltonian* $\mathcal{H}_{GR}$, as defined, does not guarantee the conservation of energy at any time in the history of our universe. There must have been, therefore, a very important additional phenomenon that may or may not involve a large number of nucleons and with a strong endothermic character. This phenomenon could have been the formation of *primordial black holes* that concentrated most of the energy of the universe, causing a drastic reduction in temperature.

The first proposal for its existence was made by Carr, B. J. and Hawking, S. W. (1974) [31] arguing that its formation would have been produced by gravitational instabilities in the early stages of the universe. Subsequently, and more recently, there have been many studies and contributions [32],[33],[34],[35],[36],[37] and [38], addressing their mechanisms of creation from different perspectives, ranging from entropy to dark matter. In addition, the latest JWST observations show very supermassive black holes, whose formation would have been impossible as a result of the collapse of a large star, since the accretion process would not have had enough time to acquire such enormous mass. Our contribution does not delve so much into the nature of its origin, but into the necessity of its existence as a guarantee of the conservation of energy in compliance with the *first law of thermodynamics*.

It also shows that the gravitational Hamiltonian described in (61) is incomplete, as it should contain a term of pure gravitational energy that could be associated with entropy. Let's not forget that entropy is a measure of non-useful energy.

$$\mathcal{H}_{GR} = \frac{3}{2} \sum_i^n \frac{N_i^2 \mathbb{E}}{N_i \mathbb{E}} + 6 \frac{\pi k_B}{c\hbar} \sum_j^m \frac{N_j^2 \mathbb{E}}{N_j \mathbb{E}} + 3\mathbb{E} \sum_{i,j}^{n+m} \mathbb{C}_n^2 \frac{N_{i,j} N_{i,j}}{d_{i,j}^3} + \mathbb{E} \sum_k^p PBH_p \quad (71)$$

The last term added represents the energy accumulated in primordial black holes developed in that early epoch of the universe, and whose nature responds to possible discontinuities in space-time, becoming true wells of gravitational energy.

We reject the probability of the existence of diffuse *dark energy* of an anti-gravitational nature in the early universe since its effects would have prevented a universe as we observe it. Likewise, if its character is gravitational, since it would have greatly accelerated the grouping of barionic matter.

The relationship between mass and energy deduced by Einstein can be expanded to give it a much broader meaning, since all baryonic matter and its self-interrelation is a form of energy. Mass is energy in two different forms: as isolated matter and as gravitationally entangled matter. $E_m = mc^2$

$$E_M = \sum_h^{m+n} m_h c^2 + \sum_i^n \frac{3}{2} \frac{N_i^2 \mathbb{E}}{N_i \mathbb{E}} + \sum_j^m 6 \frac{\pi k_B}{c\hbar} \frac{N_k^2 \mathbb{E}}{N_k \mathbb{E}} + 3\mathbb{E} \sum_{i,j}^{n+m} \mathbb{C}_n^2 \frac{N_{i,j} N_{i,j}}{d_{i,j}^3} + \mathbb{E} \sum_k^p BHP_p \quad (72)$$

where m_h is the mean mass of the nucleon. At the lower limit of $N=1$, it reduces to

$$E_M = m_h c^2 + \frac{3}{2} E_{PGM} + \mathbb{E} \sum_k^p BHP_p \quad (73)$$

Baryonic matter, because it is matter, is energy, and as baryonic matter it manifests its intrinsic nature by generating gravitational energy, the gravitational quantum by which it is mutually recognized and aggregated. $E_\mu = mc^2\mathfrak{E}$ While the energy of matter at rest has no gravitational effects on the rest of the surrounding matter, the gravitational energy $E_\mu EG$ is the engine that moves all the matter in the universe.

III. Quantum-gravitational relativistic equation

The description of the gravitational Hamiltonian (71) has important consequences in the **GRT** by establishing the equivalence between baryonic matter and gravitational energy. Consequently, if mass is gravitational energy, the *tensor of matter* must be replaced by the *tensor of gravitational energy* in the TGR equation, since it is that energy that is responsible for the geometry of spacetime.

$$G_{\alpha\beta} = \frac{8\pi}{c^4} E^{\alpha\beta} \quad (74)$$

$$E^{\alpha\beta} = E_{CO}^{\alpha\beta} + E_{AN}^{\alpha\beta} + E_{EN}^{\alpha\beta} + E_{PBH}^{\alpha\beta}$$

$$= \frac{3\mathfrak{E}}{2\mathfrak{E}} \sum_i^n N_i + 6 \frac{\mathfrak{E}}{\mathfrak{E}} \frac{\pi k_B}{c\hbar} \sum_j^m N_k + 3\mathfrak{E} \sum_{i,j}^{n+m} \mathbb{C}_n^2 \frac{N_{i,j} N_{i,j}}{d_{i,j}^3} + \mathfrak{E} \sum_k^p PBH_p \quad (75)$$

The *tensor of gravitational energy* is the sum of the tensor of the internal energy of ordinary matter, the tensor of the energy due to black holes, the tensor of the external entanglement energy and the tensor of primordial black holes. $E_{CO}^{\alpha\beta} E_{AN}^{\alpha\beta} E_{EN}^{\alpha\beta} E_{PBH}^{\alpha\beta}$

$E_{CO}^{\alpha\beta}$ it only has local effects and does not differ from the tensor of matter, since energy adopts the geometry of mass, its results being therefore the same as the **GRT**. It has local and cosmological effects whenever $E_{AN}^{\alpha\beta} N_k > 0$. E_{EN} only has effects at the cosmological level, the greater the greater n and is null for $n = 1$. The cosmological effects of the tensor are difficult to quantify due to the limited information we have, although they are likely to be the ones that most condition the geometry of our universe. The **GCT** results $E_{PBH}^{\alpha\beta}$ will differ more from the **GRT** the greater the cosmological range, coinciding in the local environment.

The simplest form of the *gravitational Hamiltonian* is by considering a single spherical body, being reduced to a local environment:

$$\mathcal{H}_{GR} = \frac{3}{2} \frac{N^2 \mathfrak{E}}{N \mathfrak{E}} = \frac{3}{2} \frac{E_{GEN}}{E_{EMI}} \quad (42)$$

And the solution to Einstein's field equation valid for the exterior of a massive body of spherical symmetry, static, uniform and neutrally electric is the Schwarzschild solution. The *element line* of this space-time is described in spherical coordinates and CGS units by the equation:

$$ds^2 = -\left(1 - \frac{2GM}{rc^2}\right)dt^2 + \frac{dr^2}{1 - \frac{2GM}{rc^2}} + r^2(d\theta^2 + \sin^2\theta d\phi^2) \quad (76)$$

where r represents the radius of the sphere with the condition $r > 2GM/c^2$.

In this assumption of a local environment, both theories coincide, **GRT** and **GCT**, since cosmological effects are only appreciable in the vicinity of black holes and in significant concentrations of stars. It will be enough to replace GM with the *local Hamiltonian*, and the new *line element* becomes:

$$ds^2 = -\left(1 - \frac{3}{rc^2} \frac{N^2 \hat{\mathfrak{G}}}{N \mathfrak{E}}\right)dt^2 + \frac{dr^2}{1 - \frac{3}{rc^2} \frac{N^2 \hat{\mathfrak{G}}}{N \mathfrak{E}}} + r^2(d\theta^2 + \sin^2\theta d\phi^2) \quad (77)$$

Now the condition for not producing a singularity is

$$r > \frac{3}{c^2} \frac{N^2 \hat{\mathfrak{G}}}{N \mathfrak{E}} = \frac{3}{c^2} \frac{E_{GEN}}{E_{EMI}} = \frac{3}{c^2} E_{PGM} N = \frac{3\hbar}{c^2} \omega N \quad (78)$$

Note that radius now depends on quantum parameters and the *quantum gravitational constant* $\hat{\mathfrak{G}}$ is absent. All relativistic physics derived from Schwarzschild's solution remains valid in the **GCT**.

Another local solution to the **GRT** equations is the one obtained by Kerr applied to the exterior of black holes. Its equivalent can also be obtained in the **GCT**, but its study and development exceed the objective of this article. Solutions at the cosmological level that include the three components of the gravitational Hamiltonian also exceed our purposes.

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