

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*.

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* $\mathfrak{G}$.
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: $V_x = \frac{1}{2} K x^2$

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

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

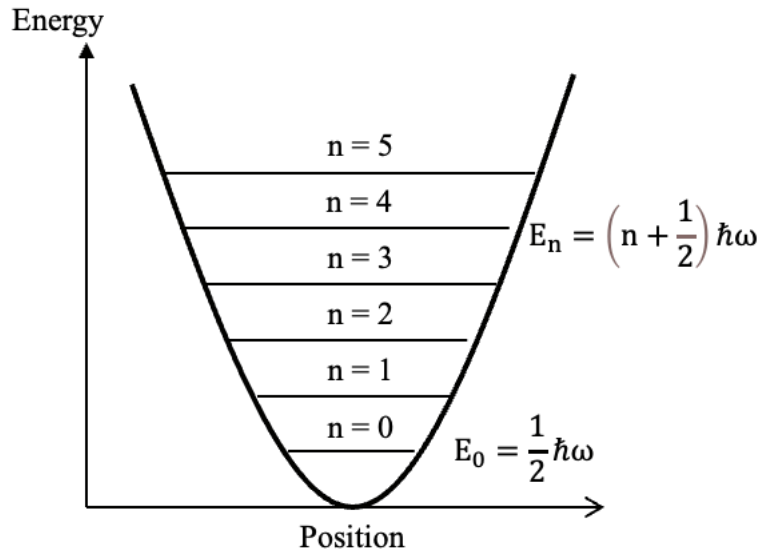
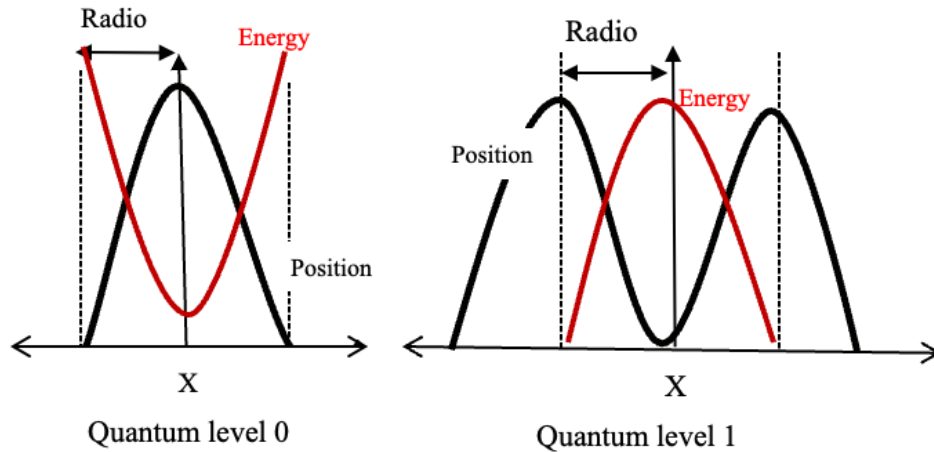


Figure 1 shows the different levels quantized as a function of energy. Quantum jumps are normalized to $\hbar\omega$.

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 $0.938272089436 \text{ GeV } /c^2$ [12] and $0.833 \pm 0.010 \text{ fm}$ [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

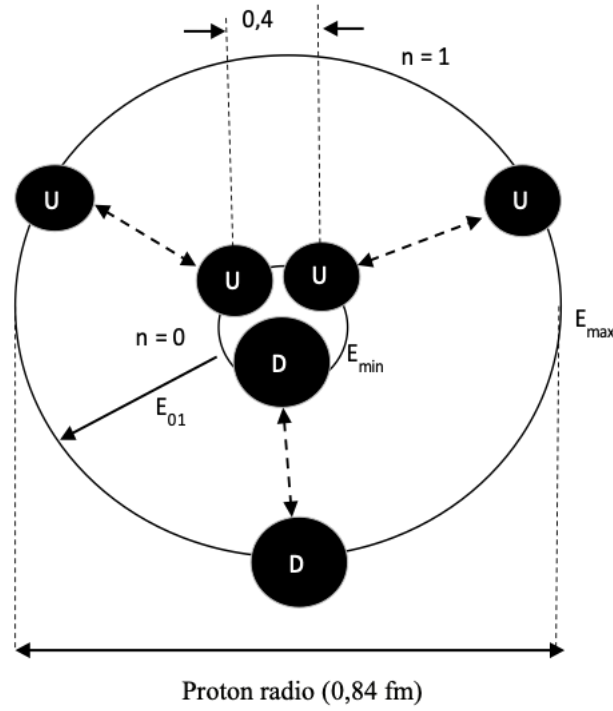


Figure 3 illustrates the distribution of the proton's quarks in their two quantum energy levels.

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 $E_{\frac{3}{2}}\hbar\omega_{01} = \hbar\omega = 0.62551472628667$ 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 $\mathfrak{E}$

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 $\mathfrak{E}$.

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

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 :

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

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:

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

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 /ev.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:

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

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*.

REFERENCE INDEX

1. Verlinde, E. P. (2016). Emergent gravity and the dark universe. arXiv:1611.02269
2. Llorenç Espinosa, Juan García-Bellido. (2021). Covariant formulation of non-equilibrium thermodynamics in General Relativity. arXiv:2106.16012v2 [gr-qc] 19 Oct 2021
3. Xjangdong Ji. A QCD analysis of the mass structure of the nucleon. arXiv:hep-ph/9410274v1 12 October 1994
4. Johnson, K. MIT-CTP-494 (1975) Acta Phys.Poland. B 6 (865)
5. Silva, P.R. Analysis of the mass structure of the hadrons, arXiv:1108.2073 [physics-gen-ph] August 2011
6. Thomas, A.W., Shanahan, P.E., Young, R.D. Strangeness in the nucleon: what have we learned? arXiv: 1202.6407 [nucl-th] 28 February 2012
7. Meyer, H.B. arXiv: 1106.3163 February 2011
8. Horsley, R. et al. arXiv: 1110.4975. October 2011
9. Shrödinger, E. An Undulatory Theory of the Mechanics of Atoms and Molecules. Phys.Rev. 28. 1049-1070 (1926)
10. Heisenberg, W. Heisenberg 1927.On the Descriptive Content of Kinematics and Quantum Theoretical Mechanics.Z.Phys.43:172-198 (1927)
11. Einstein, A. and Stern, O. Einige Argumente für die Annahme einer molekularem Agitation beim absolutem Nullpunkti. Annalen der Physik.Vol. 40:551-552
12. CODATA
13. N. Bezginov, T. Valdez, ..., E. A. Hessels, «A measurement of the atomic hydrogen Lamb shift and the proton charge radius,» Science 365: 1007-1012 (06 Sep 2019), doi: [10.1126/science.aau7807](https://doi.org/10.1126/science.aau7807)
14. Zeus Collaboration. "Limits on the effective quark radius from inclusive ep scattering ah HERA". Physics Letters B(12 Apr 2016) doi:10.1016/j.physletb.2016.04.007
15. FLAG Working Group (Sinya Aoki et al.), «Review of lattice results concerning low energy particle physics,» [arXiv:1310.8555](https://arxiv.org/abs/1310.8555) [hep-lat], 31 Oct 2013.
16. Pablo López. Naked Quark hypothesis (pending publication)
17. V. Balasubramanian, M. B. McDermott and M. Van Raamsdonk, "Momentum-space entanglement and renormalization in quantum field theory," Phys. Rev. D 86 (2012), 045014 doi:10.1103/PhysRevD.86.045014 [arXiv:1108.3568 [hep-th]].
18. Sougato Bosé, Anupam Mazundar, Martine Shut and Marko Toros. Mechanism for the quantum natured gravitons to entangle masses. arXiv: 2201.03583v3 [gr-qc] 18 May 2022
19. Sougato Bosé, Anupam Mazundar, Martine Shut and Marko Toros. Entanglement witness for the weak Equivalence Principle. arXiv: 11628v2 [gr-qc] 3 March 2023.
20. The ATLAS Collaboration, Observation of quantum entanglement with top quarks at the ATLAS detector. <https://doi.org/10.1038/s41586-024-07824-z>. 18 September 2024.
21. Sabín, C. (2023). "Digital quantum simulation of quantum gravitational entanglement with IBM quantum computers". EPJ Quantum Technology. <https://doi.org/10.1140/epjqt/s40507-023-00161-6>.

22. Marios Christodoulou, Carlo Rovelli. On the possibility of laboratory evidence for quantum superposition of geometries. arXiv: 1808.05842v2 [gr-qc] 15 October 2019
23. William M. Baker et al. A core in a star-forming disc as evidence of inside-out growth in the early Universe, *Nature Astronomy* (2024). DOI: [10.1038/s41550-024-02384-8](https://doi.org/10.1038/s41550-024-02384-8)
24. Mengyuan Xiao. Accelerated formation of ultra-massive galaxies in the first billion years. *Nature* (2024). DOI: 10.1038/s41586-024-08094-5
25. Bekenstein, J. D. (1972). Black holes and the second law. *Letters Nuovo Cimento*, 4, 737.
26. S. W. Hawking, Gravitational Radiation from Colliding Black Holes, *Phys. Rev. Lett.* 26, 1344-1346 (1971).
27. SPT-3G D1: CMB temperature and polarization power spectra and cosmology from 2019 and 2020 observations of the SPT-3G Main field,» arXiv:2506.20707 [astro-ph.CO] (25 Jun 2025), doi: <https://doi.org/10.48550/arXiv.2506.20707>
28. R. M. Soneira, P. J. E. Peebles, «A computer model universe – Simulation of the nature of the galaxy distribution in the Lick catalog, *Astronomical Journal* 83: 845-860 (1978) [[ADSABS](https://ui.adsabs.org/abs/1978AJ....83..845S)].
29. P. J. E. Peebles, "The fractal galaxy distribution," *Physica D* 38: 273-278 (1989), doi: [https://doi.org/10.1016/0167-2789\(89\)90205-4](https://doi.org/10.1016/0167-2789(89)90205-4)
30. Sloan Digital Sky Survey III. (arxiv.org/abs/1607.03155) , (arxiv.org/abs/1607.03155)
31. Carr, B. J.; Hawking, S. W. Black Holes in the Early Universe. (August 1, 1974). *Monthly Notices of the Royal Astronomical Society* 168(2): 399-415. ISSN 0035-8711. DOI:10.1093/MNRAS/168.2.399.
32. Joseph Silk, Mitchell C. Begelman, Colin Norman, Adi Nusser, and Rosemary F. G. Wyse. Which came first: supermassive black holes or galaxies? Insights from JWST. 4 Jan 2024. arXiv:2401.02482v1[astro-ph.GA]
33. Juan García-Bellido and Ester Ruiz Morales, "Primordial black holes from single field models of inflation," *Phys. Dark Univ.* 18, 47–54 (2017), arXiv:1702.03901[astro-ph.CO].
34. Julia Monika Koulen, Stefano Profumo and Nolan Smyth. Primordial Black Holes and the First Stars. arXiv:2506.06171v2 [astro-ph.CO] 5 J 2025
35. Juan García Bellido, Andrei Linde and David Wands. Density perturbations and black hole formation in hybrid inflation. *Physical Review D*. vol. 54, no. 10, pp. 6040-6058, November 1996.
36. Wenzer Qin, Sarah R. Geller, Shyam Balaji, Evan McDonough and David I. Kaiser. Planck Constraints and Gravitational Wave Forecasts for Primordial Black Hole Dark Matter Seeded by Multifield Inflation.,ArXiv: 2303.02168v2[astro-ph.CO] 12 Jul 2023
37. Sébastien Clesse and Juan García-Bellido. Primordial black holes from hybrid inflation as dark matter and the seeds of galaxies. (2015). DOI: 10.1103/PhysRevD.92.023524
38. Sophic Geris et al. JADES reveals a large population of low mass black holes at high redshift. ArXiv (2025). DOI:10.48550/arxiv.2506.22147.