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The Origin of the Accelerated Expansion of the Universe from a Gravitational Collapse in Higher Dimensions

Iván Escudero*

Universidad Complutense de Madrid, Campus Somosaguas 28223 Pozuelo de Alarcón (Madrid), Spain

***Corresponding author:** Iván Escudero, Universidad Complutense de Madrid, Campus Somosaguas 28223 Pozuelo de Alarcón (Madrid), Spain.

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Abstract

In this work, we propose an alternative theoretical model to explain the accelerated expansion of the universe, based on the gravitational collapse of a black hole in a higher- dimensional space. We suggest that this collapse causes a rupture in the fabric of spacetime, generating a new universe whose accelerated expansion is a direct consequence of this process. Through detailed calculations, we demonstrate that the current acceleration of the universe is consistent with observational data, such as those from type IA supernovae and the cosmic microwave background. Additionally, we address the problem of the universe's low initial entropy, proposing that this model provides a natural explanation for the order observed in its early stages. The results suggest that this alternative approach offers a viable explanation for cosmic expansion and raises new questions about the role of gravitational phenomena and the evolution of the universe.

Keywords: Accelerated Expansion, Quantum Bounce, Higher-Dimensional Gravitational Collapse

Introduction

The discovery of the accelerated expansion of the universe in recent decades has profoundly transformed our understanding of the cosmos. Observations of Type IA supernovae, along with studies of the Cosmic Microwave Background (CMB), have revealed that the universe not only expands but does so in an accelerated manner [1]. This phenomenon, which defies initial expectations of a deceleration driven by gravity, has been largely attributed to the influence of an unknown form of dark energy, which is believed to constitute approximately 68% of the universe's energy content [2].

Despite numerous studies, the nature of this dark energy remains one of the greatest mysteries in cosmology. Although the standard cosmological model, known as ΛCDM (Lambda Cold Dark Matter), provides a coherent mathematical description of accelerated expansion, it does not offer a clear physical explanation of what dark energy truly is or how it operates [3]. This gap in our understanding suggests the need to explore new theoretical avenues that may offer viable alternatives.

In this work, we propose a novel hypothesis that rethinks the origin of the universe's accelerated expansion. Unlike the standard paradigm, we suggest that cosmic acceleration could be related to an extreme gravitational collapse in another universe. Our hypothesis posits that the observable universe emerged from a quantum rupture process induced by this collapse, which may have generated the initial acceleration necessary to prevent a deceleration phase. This approach does not rely on the notion of dark energy as the driver of cosmic expansion, but rather proposes that the observed acceleration is the result of a physical transition in which matter and energy, compressed into a high-density state, gave rise to a rapid initial expansion due to the extreme conditions of the collapse in this higher-dimensional space.

In addition to addressing accelerated expansion, this hypothesis offers a possible solution to the problem of the universe's low-entropy initial state, another of cosmology's great enigmas. According to thermodynamics, low-entropy configurations are highly improbable compared to high-entropy states. Nevertheless, the early universe started from a very ordered state. We propose that the extreme compression of matter and information during the universe's creation process could have generated this low-entropy initial state, and that the subsequent accelerated expansion is consistent with the thermodynamic evolution of the universe we observe today.

We have developed a model that combines quantum corrections to the Schwarzschild metric to describe gravitational collapse with the Friedmann-Lemaître-Robertson-Walker (FLRW) metric to represent cosmic expansion. Through this approach, we present detailed calculations that explain the observed acceleration of the universe. In this model, the acceleration is driven by quantum density generated during the collapse, avoiding the need to introduce dark energy. To strengthen our hypothesis, we compare the results with recent observational data, demonstrating that the acceleration values derived from our model are consistent with current empirical observations.

Literature Review

The accelerated expansion of the universe is one of the most surprising and mysterious phenomena discovered in modern cosmology. From Edwin Hubble's initial observations to recent studies of the Cosmic Microwave Background (CMB) and Type Ia supernovae, our understanding of the universe's dynamics has evolved significantly. Over the decades, several cosmological models have sought to explain the universe's expansion and development, emphasizing dark energy as the main driver of cosmic acceleration. However, in recent years, fundamental questions have emerged regarding the nature of dark energy and the limitations of the standard model, justifying the exploration of alternative hypotheses.

Discovery of the Universe´s Expansion

The starting point of any discussion on the universe's expansion traces back to Edwin Hubble's work in 1929. Hubble demonstrated that the most distant galaxies were receding at speeds proportional to their distance from Earth, suggesting that the universe was expanding [4]. This relationship, known as Hubble's Law, laid the foundation for what would later become the Big Bang model, the idea that the universe began in an extremely dense and hot state, expanding ever since.

The Hubble constant (H_0), which measures the current rate of expansion of the universe, has been revised over time. The most recent results, obtained by the Planck satellite in 2018, estimate a value of 67.4 km/s/Mpc. However, independent studies based on Type IA supernovae indicate a slightly higher value [2]. This discrepancy, known as the "Hubble tension," highlights unresolved complexities in the precise measurement of the universe's expansion rate.

Discovery of the Accelerated Expansion and the Dark Energy Problem

The most revolutionary discovery in modern cosmology occurred in 1998, when teams led by Perlmutter, Riess, and Schmidt observed that the universe was not only expanding but doing so at an accelerated rate. These studies, based on observations of Type Ia supernovae, revealed that the redshift of distant galaxies was greater than expected, implying that the universe's expansion rate was increasing over time [5].

This finding led to the introduction of the concept of dark energy, a form of energy with negative pressure that would be responsible for cosmic acceleration. Dark energy is incorporated into the standard cosmological model through the cosmological constant Λ, giving rise to the ΛCDM (Lambda Cold Dark Matter) model [6]. This model suggests that approximately 68% of the universe's energy content is composed of dark energy, while dark matter accounts for about 27%, and ordinary baryonic matter only 5% [2]. However, the nature of dark energy remains one of the great mysteries of modern physics.

Limitations of the ΛCDM Model and the Initial Entropy Problem

While the ΛCDM model is the standard framework for describing the universe, it has significant limitations. The most evident is the lack of a concrete physical explanation of what dark energy is. In this context, dark energy is treated as a term in Einstein's equations, but without a clear origin in the fundamental laws of physics. Additionally, the model does not satisfactorily address the problem of the universe's low initial entropy.

The early universe appears to have started in a low-entropy configuration, which is surprising from a thermodynamic perspective. The second law of thermodynamics indicates that systems tend to evolve towards states of higher entropy, meaning greater disorder. However, the early universe was in a highly ordered state, raising the question of why it began in such a special and unlikely configuration [7]. This problem has been extensively discussed by authors such as Roger Penrose, who has argued that the low initial entropy may be related to the structure of spacetime at the moment of the Big Bang [8].

Theoretical Alternatives to Dark Energy

Since dark energy remains a poorly understood theoretical entity, various physicists have explored alternatives that could explain accelerated expansion without resorting to a mysterious form of energy. One of the most notable proposals is the idea that cosmic acceleration could result from modifications to the laws of gravity on cosmological scales.

Theories such as f(R) gravity and models based on brane theory, like those of Randall and Sundrum, suggest that gravity could behave differently at large distances [9]. In the context of extra dimensions, our three-dimensional universe could be a brane embedded in a higher-dimensional space (the bulk), and gravitational interaction with this higher-dimensional space could be behind cosmic acceleration. These models have had some success in explaining the acceleration without requiring dark energy, though they also present theoretical and observational challenges [10].

Another possible explanation for the universe's acceleration arises from quantum gravity theories. Loop quantum gravity is one of the leading theories that attempts to unify general relativity with quantum mechanics. In this framework, it has been suggested that quantum corrections to spacetime could avoid the formation of a classical singularity in the Big Bang and instead generate a quantum bounce, giving rise to the accelerated expansion we observe today [11].

Another interesting approach is the study of cosmological singularities. Fernández-Jambrina and Lazkoz have investigated the possible futures of the universe based on the emergence of cosmological singularities, such as the Big Rip or the Big Crunch, where extreme gravitational tensions can tear spacetime apart [12]. These models focus on how dark energy or gravitational interactions could lead to final outcomes where the universe either collapses or fragments.

Recently, Ambjørn and Watabiki have proposed a theory suggesting that the current acceleration of the universe could be caused by the fusion of our universe with other "baby" universes [13]. This approach, which eliminates the need for a cosmological constant, introduces a modification to the Friedmann equations, demonstrating how the influence of these external universes could explain the expansion rate without invoking dark energy.

Quantum Rupture and the Origin of Accelerated Expansion

Within this theoretical framework, our hypothesis proposes that the observable universe could have been generated from a quantum rupture process during the gravitational collapse of a black hole in another universe or higher-dimensional space. This process, in which matter and energy compressed into a high-density state reach a critical threshold, could have led to a rupture, resulting in the rapid initial expansion of our spacetime, which would explain the acceleration we observe today.

Lee Smolin's hypothesis, known as Cosmological Natural Selection, suggests that black holes generate new universes each time they collapse [14]. In his model, "baby" universes inherit slightly different cosmological parameters, and over multiple generations, the universes that produce more black holes tend to prevail, in a process analogous to biological natural selection. This continuous cycle of universe creation and mutation posits that black holes play a fundamental role in cosmic reproduction, leading to an evolution of universes dominated by those that generate more black holes.

In contrast, our hypothesis suggests that only black holes that reach a sufficiently large critical mass to tear the fabric of spacetime can generate a new universe. Rather than a continuous process of universe creation, we propose that the collapse of these critical black holes in higher-dimensional space triggers a quantum rupture that gives rise to a new, expanding spacetime. This new universe accelerates due to the initial momentum generated by the collapse.

Gravitational collapse is well described by the Schwarzschild metric for uncharged, non-rotating black holes, which represents the geometry of spacetime around a collapsed mass [15]. However, when quantum effects are incorporated, as proposed by loop quantum gravity, this singularity may be replaced by a quantum transition that generates a new expanding spacetime, similar to a quantum bounce [16].

Our hypothesis also addresses the problem of the low initial entropy, suggesting that the universe originated from a compressed, high-density state in which entropy was limited by the nature of the gravitational collapse. This special low-entropy state may have resulted from the extreme compression of information and energy from the black hole in the other universe, explaining the highly ordered initial configuration of the universe.

Model: Quantum Transition and Accelerated Expansion

As previously mentioned, we propose that the observable universe emerged from an extreme gravitational collapse in a higher-dimensional space, in which the classical singularity of a black hole was avoided through a quantum transition. This transition allowed for the generation of a new, rapidly expanding universe, rather than an infinite singularity. To describe this process, we employ a modified quantum metric based on ideas from Loop Quantum Gravity (LQG) and the Friedmann equations for subsequent cosmic expansion.

Modified Quantum Metric

In the classical framework, the gravitational collapse of a black hole is described by the Schwarzschild metric [15, 17]:

$$ds^2 = -\left(1 - \frac{2GM}{r}\right)dt^2 + \left(1 - \frac{2GM}{r}\right)^{-1} dr^2 + r^2 d\Omega^2 \tag{1}$$

Where:

- ds^2 is the spacetime interval.
- G is the gravitational constant.
- M is the mass of the black hole.
- r is the radial coordinate from the singularity.
- $d\cap^2$ is the angular differential in spherical coordinates.

As the collapse progresses, r approaches zero, and the term $\frac{2GM}{r}$ becomes dominant, leading to a classical singularity. However, when quantum effects are included, this behavior is altered. Instead of collapsing into an infinite singularity, the quantum density becomes sufficiently high to generate a "bounce".

To model this behavior, we introduce the term $_{E_q}(r)$ into the Schwarzschild metric, which becomes relevant near the event horizon and the singularity. This leads to a modified quantum metric:

$$ds^2 = -\left(1 - \frac{2GM}{r} + \epsilon_q(r)\right)dt^2 + \left(1 - \frac{2GM}{r} + \epsilon_q(r)\right)^{-1} dr^2 + r^2 d\Omega^2 \tag{2}$$

The term $\text{c}_q(r)$ represents the quantum corrections that prevent the classical singularity. We assume that this term takes the form:

$$\epsilon_q(r) = \frac{L_p^2}{r^2} \tag{3}$$

Where L_p is the Planck length, $L_p \approx 1.616 \times 10^{-35} m$, and r is the radial coordinate. This quantum correction becomes dominant when r is very small, smoothing the gravitational collapse and preventing the formation of a classical singularity.

Conditions for the Quantum Bounce

The bounce occurs when the quantum density surpasses the classical gravitational force. This phenomenon is described by the equality between the gravitational and quantum terms in the metric:

$$\frac{2GM}{r} = \epsilon_q(r) \tag{4}$$

Substituting $\epsilon_q(r) = \frac{L_p^2}{r^2}$, we obtain the following equation for the critical radius r where the quantum transition occurs:

$$\frac{2GM}{r} = \frac{L_p^2}{r^2} \quad (5)$$

Solving for r, we obtain the critical radius r_{bounce} where the bounce occurs:

$$r_{bounce} = \frac{L_p^2}{2GM} \quad (6)$$

This radius r_{bounce} represents the quantum scale at which gravitational collapse halts, and spacetime begins to expand, giving rise to a new universe.

Expansion of the New Universe: FLRW Metric

After the bounce, spacetime begins to expand, which can be described by the Friedmann- Lemaître-Robertson-Walker (FLRW) metric [18–21], which models a homogeneous and isotropic expanding universe:

$$ds^2 = -dt^2 + a(t)^2\left[\frac{dr^2}{1-kr^2} + r^2 d\Omega^2\right] \quad (7)$$

Where:

- $a(t)$ is the scale factor, which describes how the universe expands over time.
- k is the spatial curvature, which can be k=0 (flat), k=1 (positive curvature), or k=−1 (negative curvature).

The evolution of the scale factor $a(t)$ is determined by the Friedmann equations, which relate the universe's expansion rate to the energy density ρ and the pressure p of the universe's contents.

Fiedmann Equations and Accelerated Expansion

To describe the accelerated expansion of the new universe, we use the second Friedmann equation, which relates the acceleration of the expansion to the dominant quantum energy density:

$$\frac{\ddot{a}}{a} = \frac{8\pi G}{3}\rho_{quantum} \quad (8)$$

Where:

- $\ddot{a}$ is the acceleration of the scale factor.
- G is the gravitational constant.
- $p_{quantum}$ is the dominant quantum energy density after the bounce.

In this model, the quantum density $p_{quantum}$ acts as the driving force behind the accelerated expansion of the universe, in a manner like the dark energy observed today.

Results

Calculation of the Observed Acceleration

The deceleration parameter q_0 is used to describe whether the universe's expansion is accelerating or decelerating. A negative value of q0 indicates that the expansion is accelerating. According to modern observations of Type Ia supernovae, the empirical value of q_0 is approximately -0.55 [22].

The physical acceleration $\ddot{a}$ can be related to this deceleration parameter through the following equation:

$$\ddot{a} = -q_0 H_0^2 \quad (9)$$

Where:

- H_0 = 2.268 × 10−18s−1 is the Hubble constant.
- q_0 ≈ −0.55 is the empirical deceleration parameter. By substituting these values:

$$\ddot{a} = -(-0.55) \times (2.268 \times 10^{-18} s^{-1})^2 \approx 2.83 \times 10^{-36} s^{-2}$$

This value corresponds to the acceleration of the scale factor. To obtain the physical acceleration at a typical cosmological distance, such as the size of the observable universe (d ≈ 8.80×1026 m), we scale this value as follows:

By substituting the values:

$$a_{obs} = \ddot{a} \cdot d \quad (10)$$

$$a_{obs} = (2.83 \times 10^{36} s^{-2}) \times (8.80 \times 10^{26} m) \approx 2.49 \times 10^{-9} \mathrm{m/s^2}$$

Comparison with Acceleration Derived from Hubble´s Law

Hubble's Law describes the relationship between the recession velocity of galaxies (v) and their distance (d) from the observer, expressed by the equation:

$$v = H_0 \cdot d \quad (11)$$

This law indicates that the farther away a galaxy is, the faster it recedes from us, reflecting the expansion of the universe.

For the calculations, we use the following observational parameters:

- Size of the observable universe: d ≈ 8.80 × 1026m.
- Hubble constant: H_0 = 2.268 × 10−18s−1.
- Age of the universe: t ≈ 4.35 × 1017s.

The expansion velocity at the edge of the observable universe can be calculated using Hubble's
law:

$$v = H_0 \cdot d = (2.268 \times 10^{-18} s^{-1}) \times (8.80 \times 10^{26} m) = 1.995 \times 10^9 m/s$$

This means that the farthest galaxies we can observe are receding from us at a velocity close to 2 × 10^9m/s, approximately 0.67% of the speed of light.

The effective acceleration can be calculated by dividing the recession velocity by the age of the universe:

$$a_{Hubble} = \frac{v}{t} = \frac{1.995 \times 10^9 m/s}{4.35 \times 10^{17} s} \approx 4.59 \times 10^{-9} m/s^2 \quad (12)$$

Both values fall within the same range, indicating that both the observed acceleration and the one calculated from Hubble's Law are consistent with empirical data.

Consistency of the Quantum Model with Observed Acceleration

The acceleration generated by the quantum density $p_{quantum}$ is described by the second Friedmann equation:

$$\frac{\ddot{a}}{a} = \frac{8\pi G}{3}\rho_{quantum} \quad (13)$$

We know that the observed acceleration is $a_{obs} \approx 2.49 \times 10^{-9} m/s^2$. To compare this acceleration with the quantum model, we solve for $p_{quantum}$ from the Friedmann equation:

$$\rho_{quantum} = \frac{3}{8\pi G}\frac{\ddot{a}}{a}$$

By substituting the known values, with $G = 6.674 \times 10^{-11} m^3 kg^{-1} s^{-2}$ and the observed acceleration $\frac{\ddot{a}}{a} \approx 2.49 \times 10{-}9m/s2$:

$$\rho_{quantum} \approx \frac{3}{8\pi(6.674 \times 10^{-11})}(2.49 \times 10^{-9}) \approx 1.48 \times 10^{-26} kg/m^3$$

This value of quantum density is comparable to the critical density of the universe, which is $p_{critical} \approx 8.5 \times 10^{-27} kg/m^3$. The result demonstrates that the proposed model is consistent with the observed acceleration of the universe.

This analysis shows that the quantum bounce predicted by our model provides an acceleration consistent with current observations, and that the behavior of the universe observed today can be explained by this initial quantum process. Additionally, the observed acceleration $a_{obs} \approx 2.49 \times 10\text{-}9m/s^2$ could be a direct reflection of the quantum density resulting from gravitational collapse in higher dimensions.

Consistency of the Quantum Model with Acceleration Derived from Hubble´s Law

We again use the second Friedmann equation to relate the acceleration to the quantum density $p_{quantum}$:

$$\frac{\ddot{a}}{a} = \frac{8\pi G}{3}\rho_{quantum'} \quad (13)$$

By substituting the value of the acceleration derived from Hubble's Law $a_{Hubble} = 4.59 \times 10^{-9} m/s^2$ and $G = 6.674 \times 10^{-11} m^3 kg^{-1} s^{-2}$, we can solve for the quantum density $p_{quantum'}$:

$$\rho_{quantum'} \approx \frac{3}{8\pi(6.674 \times 10^{-11})}(4.59 \times 10^{-9}) \approx 2.73 \times 10^{-26} kg/m^3$$

Again, this value is very close to the critical density of the universe $\rho_{critical} \approx 8.5 \times 10^{-27} kg/m^3$, indicating that the model is also consistent with the acceleration derived from Hubble's Law.

Discussion

Our hypothesis proposes that the accelerated expansion of the universe is the result of an initial impulse generated by the gravitational collapse of a black hole in a higher-dimensional space. In this scenario, the extreme collapse would have led to the creation of our observable universe, providing the driving force that has sustained accelerated expansion over time. Unlike the standard cosmological model, which posits an initial phase of deceleration followed by acceleration attributed to dark energy, our hypothesis eliminates the need for this additional theoretical component.

The model we propose is based on quantum corrections applied to the Schwarzschild metric, which avoid the classical singularity through a quantum bounce. This approach is inspired by recent advances in Loop Quantum Gravity (LQG), which postulates that spacetime is discrete at Planck scales. According to LQG, extreme gravitational collapse does not lead to an infinite singularity but to a state where quantum effects prevent physical quantities from diverging, allowing for the birth of a new expanding universe. The unification of this theory with general relativity remains a theoretical challenge, but our model aligns with the basic principles of LQG.

Despite the qualitative similarities between our model and the ΛCDM model in terms of the accelerated expansion of the universe, quantitative differences in predictions may offer a pathway for future observational tests. For instance, our model predicts a quantum density slightly higher than the critical density calculated in the standard model. This difference could be reflected in future observations, particularly in measurements of cosmic expansion at different epochs of the universe.

Another key aspect of our hypothesis is its consistency with the low initial entropy problem of the universe, as posed by Roger Penrose [23]. According to this problem, the universe would have begun in a low-entropy state, which is surprising from a thermodynamic perspective, as we would expect a state of maximum entropy at the start. We propose that the gravitational collapse in the higher-dimensional space, which may have created our universe, generated this low-entropy state. By analogy with black holes, where the event horizon is associated with an increase in entropy, we suggest that the process of creating the observable universe could have generated a high-density, low-entropy state in its early stages. This approach resolves one of cosmology's most challenging problems, providing a natural explanation for the low initial entropy. The extreme compression and subsequent quantum bounce would have restricted entropy, keeping it low, which is consistent with current observations of the early universe.

Our hypothesis is also consistent with recent observations, such as the Pantheon+ dataset of Type Ia supernovae, which supports an accelerated expansion model [24]. While the standard model posits that acceleration was preceded by a phase of deceleration, we suggest that cosmic expansion was constant or even increasing from the beginning. This approach could also explain the well- known "Hubble tension," the discrepancy between the values of H_0 obtained from observations of the local universe and those calculated from the Cosmic Microwave Background (CMB). We propose that changes in acceleration, derived from variations in the initial gravitational collapse, could have influenced measurements at different epochs of the universe.

The results show that the observed acceleration of the universe, derived from the deceleration parameter H_0, is consistent with the acceleration calculated through Hubble's Law. This reinforces the validity of the model, which predicts a similar acceleration through the quantum density resulting from gravitational bounce. The calculations of quantum density in this model are close to the current critical density of the universe, suggesting that accelerated expansion can be naturally explained without the need for additional energy components.

In this sense, our model also differs from dynamic dark energy theories, such as those proposed by Andrei et al., which suggest the decay of dark energy or quintessence models as drivers of expansion [25]. While those models posit a change in the nature or quantity of dark energy over time, we suggest that cosmic acceleration has been directly driven by a gravitational process, where the collapse of a black hole in higher-dimensional space triggered the creation of a universe. This approach not only simplifies cosmological dynamics by eliminating the need for an additional theoretical component but also provides a more solid physical basis by linking the universe's origin to a well-known process in gravitational physics.

The hypothesis presented in this work opens new lines of investigation in cosmology and quantum gravity. One of the most interesting aspects of this model is its ability to rethink the role of black holes in the structure and evolution of the universe. Rather than being simply regions of irreversible collapse, black holes could be points of creation for new universes, in line with Lee Smolin's ideas. This raises fundamental questions that deserve further exploration: What is the critical mass threshold that a black hole must reach to tear spacetime and generate a new universe? Must the black hole reach an extraordinary mass, or could spacetime tearing occur under specific quantum conditions? Conversely, can spacetime support any supermassive object without tearing?

The answer to these questions could lead us to a deeper understanding of the role of black holes in the dynamics of the universe and their relationship to the creation of new universes. Additionally, this model suggests that cosmic expansion is not an isolated phenomenon but is intrinsically linked to gravitational collapse in higher-dimensional spaces. The proposal that a black hole can generate an entire universe offers an intriguing path for investigating the limits of spacetime and the extreme quantum conditions that allow the creation of new regions of the cosmos.

Despite the theoretical advantages of the proposed model, there are some limitations that must be addressed in future research. First, this work is based on principles of quantum gravity, which have yet to be fully unified with general relativity. While advances in Loop Quantum Gravity suggest that it is possible to avoid the formation of classical singularities, the complete formulation of a quantum gravity theory remains a challenge. Moreover, experimental validation of this model faces

significant obstacles, as the phenomena involved occur at extremely high energy scales, close to the Planck length. However, future observations of the CMB or gravitational waves may contain indirect signals supporting the existence of a quantum bounce like the one proposed here.

Finally, a future line of research would be to explore how the quantum density postulated in this work interacts with other forms of energy present in the universe, such as radiation or dark matter. These interactions could have significant implications for the evolution of the universe and should be considered in more detailed versions of the model.

Conclusions

In this work, we have presented an alternative model to explain the accelerated expansion of the universe, based on the hypothesis that the observable universe emerged because of gravitational collapse in a higher-dimensional space. This approach suggests that the cosmic acceleration we observe today is a direct consequence of the initial impulse generated by such a collapse, eliminating the need to introduce dark energy as an additional component to justify the accelerated expansion.

The calculated value of the current acceleration of the universe is consistent with modern observations of Type Ia supernovae and the Cosmic Microwave Background (CMB), reinforcing the coherence of our proposal. Moreover, calculations based on the deceleration parameter q^0 yield results of the same order of magnitude as the available empirical data, suggesting that our approach is compatible with current cosmological observations. The quantum density derived from the model falls within a range close to the universe's critical density, further supporting the viability of our hypothesis without the need to postulate a cosmological constant or dark energy.

Although our model differs from the standard ΛCDM paradigm, which posits dark energy as the primary driver of cosmic acceleration, this work offers an alternative that simplifies the dynamics of the universe. Instead of relying on an exotic form of energy with unknown properties, we propose that gravitational collapse may be the driving force behind the accelerated expansion from the universe's beginnings. This approach not only resolves the problem of the classical singularity through a quantum bounce, but also naturally addresses the problem of the universe's low initial entropy.

However, we acknowledge that further research is needed to fully assess the viability of this hypothesis. Deeper analysis is required to explore how this approach can explain other cosmological phenomena, such as large-scale structure formation and the discrepant measurements of the Hubble constant. The tension between different values of H_0, obtained from nearby observations and the CMB, may find a possible explanation within the framework of our model, as it suggests variations in cosmic acceleration caused by the initial gravitational collapse.

While the results obtained are consistent with current observations, it is essential to approach the development of alternative models in cosmology with caution. The proposal presented in this work raises questions about the mechanisms responsible for accelerated expansion and the possible influence of gravitational phenomena in higher dimensions. More theoretical and observational studies are needed to evaluate the robustness of this hypothesis in a broader cosmological context and to better understand the interactions between quantum density and other forms of energy present in the universe, such as radiation and dark matter.

In summary, this work opens new avenues of research in cosmology and quantum gravity, providing a solid theoretical foundation for future explorations of the universe's origin and evolution without relying on dark energy. Nevertheless, the experimental validation of this model remains a challenge due to the extremely high energy scales involved. Future studies will need to address these obstacles and determine whether this approach can offer a comprehensive explanation for the observed cosmological phenomena.

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