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A Resolution to the Vacuum Catastrophe: The Role of the Omniom Vacuum

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Abstract

The cosmological constant problem, or vacuum catastrophe, highlights the enormous gap between observed vacuum energy density and the vastly larger values predicted by quantum field theory, often differing by 120 orders of magnitude. This discrepancy presents a significant challenge to our understanding of the universe. Originally introduced by Einstein to allow for a stationary universe, the cosmological constant was abandoned after Hubble's discovery of the universe's expansion, only to be revisited with the discovery of the accelerating expansion, driven by dark energy. Today, the cosmological constant is regarded as a low-energy effective theory of dark energy, but it fails to explain the full nature of the vacuum. This work proposes the concept of the Omniom vacuum, a primordial state that existed before the Big Bang, with a static density estimated through fundamental constants to be approximately 9.51×10^{-27} kg/m^3. This Omniom vacuum served as the infinite container within which the universe's expansion began. As the universe expanded, part of this vacuum condensed into matter and dark matter, while the remaining portion evolved into dark energy, which has a lower density than the original Omniom vacuum. The density of dark energy is observed to be around 5.91×10^{-27} kg/m^3, whereas the Omniom vacuum before the Big Bang maintained a higher density. Additionally, at the moment of the singularity, the universe's density spiked to the Planck density, approximately 5.155×10^{96} kg/m^3, revealing a stark contrast with the more stable Omniom vacuum. This framework provides a new perspective on vacuum energy and cosmology, distinguishing between the primordial Omniom vacuum, the dark energy driving current cosmic expansion, and the extreme density of the singularity at the universe's birth. By clarifying these distinctions and calculating the density of the Omniom vacuum through constants like the speed of light, vacuum permittivity, and gravitational constant, this work offers fresh insight into the cosmological constant problem and a pathway toward resolving the mystery of the universe's accelerating expansion.

Keywords

Cosmological Constant, Vacuum Density, Dark Energy Density, Singularity Density, Fundamental Constants

1. Introduction

The cosmological constant problem, referred to as "vacuum catastrophe", is in many ways one of the greatest mysteries of theoretical physics. This problem arises primarily due to the observation of the vacuum energy density value which is associated with cosmological constant, and the value prediction obtained through theoretical models of vacuum energy density. It is typical in quantum field theory to predict vacuum energies on the order of 120 orders or powers more than those known, which counts as one of the great problems in science today [1].

At first, when the cosmological term was brought by Einstein through an equation as an addition to general relativity theory, it was conceived to permit a stationary universe. However, after Edwin Hubble discovered that the universe was expanding, it is said that Einstein used the term cosmological constant as his greatest blunder.

Even so, the idea was brought back decades of history after when observations of remote types of supernovae established that the expansion of the universe is not only happening but is actually speeding up [2] [3].

This accelerated expansion implies the existence of an energy that originates from nowhere and extends across space and time and causes the acceleration such as in cosmology dark energy (as different from dark matter), where the cosmological constant is frequently considered to be a low energy effective theory of dark energy [4].

Nonetheless, the issue arises when one goes to combine such a cosmological constant with the assumptions of quantum field theory. The theory gives a vacuum energy density which is utterly unreasonable according to the rate at which the universe is being observed to expand. This has given rise to what is referred to as the "problem of cosmological constant" or rather "the vacuum's catastrophe" since it points to an even more fundamental error in understanding vacuum energy and its contribution to the universe [5].

To address this issue, various approaches have been proposed, including modifications of gravity, the introduction of new fields or particles, and even anthropic arguments. Yet, none of these solutions have satisfactorily resolved the problem, leaving it as a central challenge in the quest for a deeper understanding of the universe [6] [7].

The current work takes a fresh viewpoint on this old issue and proposes a division of the quantum vacuum state into two—"real vacuum", or "Omniom", and the quantum vacuum filled with pairs of condensed and radiation particles. Our aim was to broaden the perspective by clearing the definition of vacuum energy and distinguishing these two different concepts to resolve this cosmological catastrophe.

2. The Quantum Vacuum: Current Understanding

Usually, the concept of physics known as classical guarantees that the vacuum is empty without any matter present. This is however done very differently in quantum mechanics. A quantum vacuum, however, is not simply an unfilled void as it contains and is "active" with energy. Such thoughts of the vacuum being a physical entity were put forth by Paul Dirac who first imagined the zero-point bosonic sea composed of particles in negative energy states [8].

This paradigm seeks to encourage the emergence on the viewpoint that what is referred to as the vacuum does not mean that it is empty, inside it there are some swells of quantum activity.

This comprehension is based upon the quantum fluctuations. In quantum mechanics, the so-called Heisenberg uncertainty principle holds that such fluctuations are energy perturbations happening at certain time coordinates of an otherwise empty epoch, which makes vacuum as quite the opposite extreme, an energy-field of instability [9].

These variations can be classified as a constant of virtual particles formation and splitting which leads to the Zero-point energy (ZPE) phenomenon.

It is with this ZPE concept that most of the fundamental advances in physics literature began. It was however only until the early 20th century that one physicist from Germany named Max Planck put forward this phenomenon where all motion simply does not exist in a vacuum absolute zero resistance [10].

The concept of zero-point energy, or ZPE began to appear in the works of Robert Mulliken and others who reported experiments where spectral lines changed and could only be attributed to the presence of such an energy environment ZPE [11] [12].

Quantum Electrodynamics (QED) also master's its vacuum state after the deformation of the zero point in this sense and that state is the lowest energy state. For example, it has been found that the vacuum posited in QED contains no state that lacks cavities or ions but rather, charge and fluctuating electromagnetic fields, which can have real consequences such as the Casimir force—the attractive force between 2 uncharged plates that has been predicted by Casimir in 1948 [13].

The granular structure of the vacuum, or the spacetime continuum, as one traverses the Planck length is another captivating implementation in present-day theoretical physics—that space when stretched to such extreme scales about (10^{-35}) meters where space was thought to be smooth ended up becoming frothy because of the weak gravitational interactions postulated by John Wheeler 1955 [14].

And thus, at such distances around the plans scale, the interactions of the vacant space with fundamental forces may change in a way that could account for dark matter and energy [15].

3. Exploring the Pre-Big Bang Vacuum: Introducing Omniom

What existed before the Big Bang, more than ever poses and answers the fundamental issue in cosmology and theoretical physics. For now, the explanation of the creation of the universe is surely limited, but enriching with many theories and assumptions, there has been no tangible explanation out there.

The idea of "before" the Big Bang is vaguely defined in contemporary physics. Majority of the accounts place the Big Bang as the event which arose out of singularity, a state of unimagined density and temperature. In this concept, it is assumed that time and space began to expand having the Big Bang as a temporal marker after which the normal laws of physics as known among human beings ceased to exist. It is currently not possible to say what, if anything happened during the time preceding this, nor will any models made explain what a hypothetical state that existed before the Big Bang would look like.

Wishing to comprehend the being that was before the Big Bang, the authors must consider the fundamental difference between space, energy and matter. As predicted by the Big Bang Theory, there was no space nor time prior to the Big Bang so there was no way a void in the sense in which we do is comprehensible.

In the field of quantum physics, vacuum energy is a quantum fluctuation energy of region of space. This energy is not due to any material body or radiation. But even this quantum vacuum may not have existed before the Big Bang.

We come up with a neologism "Omniom" to name that medium which existed before the universe came into being [16].

This term avoids confusion with the other concepts which are associated in some way with the vacuum, for instance, vacuum energy, zero point energy, dark energy, and so on. The usefulness of this new term means that there is no ambiguity in debates on how each specific theory is named to ensure that the arguments present are sound.

"Omniom": The structure was formed from prefixes "omni-" meaning "all", "everywhere" and the word "om" which is regarded as a symbol of God in some eastern religions. "Om" is a word of power and a symbol of religion, representing everything—the past, the present, and the future, all that was, is and will be.

Considering the phrases defining "Omniom" in this context, one could choose to look at it more as a continuation of this divine as a whole. It infers absolutely nothing like a perfect sphere which only exists in theories or maths, rather as the very center from which all forces are derived—it is what makes existence possible without any limits, pervading all at once, the container and glue that binds the universe with its basic characteristics.

So, "Omniom" is an auspicious term, yet another word that describes an entity or describes a principle which not only captures the sacred sound of "Om" but also signifies something fundamental and universal to the universe. It provides a very strong element of a description of the state before the Big Bang which should be interwoven in broad range of reality from the minimalistic fragment to the totality of universe.

4. The Density of the Omniom

The vacuum, or the "Omniom", is considered omnipresent, meaning it extends everywhere without a defined size, shape, center, direction, or time. It's immovable and forms the very foundation of the universe. This makes vacuum density a fundamental property of the universe, expected to be uniform across different scales—whether subatomic, astronomical, or cosmological.

The basic idea of universal density defines the interest of many cosmologists for several decades. This is a general understanding since Edwin Hubble proposed that the universe is expanding back in the early 20s. This expansion would suggest that galaxies and other matters are further apart thus lowering the density over time. However, in order to preserve the homogeneity of the density of the universe, certain components have to be undergoing actions that inverse this reduction. That is, on the expansion of the universe, there are those regions which will get low density and there are those which will increase in density thus forming dark energy and dark matter.

If the universe has a constant mass and it keeps on expanding hence increasing the volume, density ρ will have to decrease. However, if there is a creation of new matter all the time to compensate this fall, hence the total mass is on the rise resulting in which the density remains constant.

In order to determine this average density and put it in comparison with density of the vacuum prior to the Big Bang, it is necessary to assess the processes of formation of the new matter which was discussed in detail in previous article [17].

The density of the universe is a critical concept in cosmology, helping us understand its large-scale structure and evolution. The universe's expansion, as governed by the Hubble constant (H_0), allows us to calculate various cosmological parameters, including the inertial mass and volume of the observable universe. Although there is no consensus on the exact value of vacuum density, it is closely tied to the principles of general relativity. By observing the curvature of space-time and the expansion of the universe, it becomes possible to estimate the energy density of the universe.

One of the primary ways to measure this expansion is through the Hubble Law, which describes the relationship between the velocity of galaxies (v) and their distance from us (d) as:

$$v = H_0 \times d$$

This law indicates a constant expansion of the universe, where more distant galaxies move away faster than those closer to us. The most recent measurements, such as those by Bonvin *et al.* [18], suggest that the value of the Hubble constant (H_0) is:

$$H_0 = 71.9 - 3.0 + 2.4 \text{ km/s/Mpc} = 2.33 \times 10^{-18} \text{ s}^{-1}$$

Another similar estimation for H_0 = 71.17 km·s^{-1}·Mpc^{-1} (a 3.5% uncertainty) [19].

Given that the number of kilometres in a megaparsec (Mpc) is 3.09×10^{19}, we can calculate other cosmological parameters. For example, the inertial mass of the observable universe (M_U) is given by:

$$M_U = c^3/2H_0G = 8.77\times10^{52}\ \text{kg}$$

And the volume of the universe (V_U) is:

$$V_U = 4/3\pi R_U^3 = 4/3\pi\left(c/H_0\right)^3 = 9.22\times10^{78}\ \text{m}^3$$

From this, the cosmological density (ρ) is:

$$\rho = M_U/V_U = 9.51\times10^{-27}\pm1.05\ \text{kg/m}^3$$

Another approach to estimate the total density of the universe involves using the critical density equation:

$$\rho_c = 3H_0^2/8\pi G$$

where

H_0 is the Hubble parameter $H_0 \approx 71.9$ km/s/Mpc.

G is the constant of gravitation ≈ $6.674\times10^{-11}\ \text{m}^3\cdot\text{kg}^{-1}\cdot\text{s}^{-2}$.

This gives a critical density

$$\rho_c \approx 3H_0^2/8\pi G = 9.71\times10^{-27}\ \text{kg/m}^3\ ,$$

which represents the density at which the universe's expansion balances the vacuum energy density.

We get the current density of the universe of:

$$\rho_c \approx 3H_0^2/8\pi G = 9.71\times10^{-27}\ \text{kg/m}^3\ .$$

This value closely aligns with the calculated cosmological density and is interpreted as the Omniom vacuum density—a fundamental density value derivable from the constants of nature. It supports the idea that the universe's large-scale dynamics and structure are governed by an equilibrium between expansion and energy density rooted in the properties of the vacuum itself.

5. The Density of the Omniom Vacuum through Fundamental Constants

The Omniom vacuum can be understood as behaving like a superfluid, with measurable physical properties such as permittivity, permeability, and elasticity. These properties are reflected in several fundamental constants, including the speed of light (c), vacuum permittivity (ϵ_0), magnetic permeability (μ_0), and the gravitational constant (G), all of which relate to the vacuum's density. By examining these constants, we can calculate the density of the vacuum.

This approach highlights that the density of the Omniom vacuum is not just a theoretical concept but a measurable property grounded in the fundamental constants of physics. The vacuum's behavior as a superfluid with well-defined characteristics, such as elasticity viscosity and density, suggests that it plays a far more active role in shaping the structure of space-time than is often appreciated. Understanding the vacuum's density through these constants allows us to probe deeper into the nature of the universe, both before and after the Big Bang, and offers a pathway to reconciling quantum field theory with cosmological observations.

6. Obtaining the Vacuum Density through the Speed of Light

The speed of light itself is directly connected to the vacuum's elasticity and density, which can be expressed by the following formula:

$$c = \left(E/\rho\right)^{1/2}$$

where ρ is the density of the vacuum and E is the elasticity of the vacuum has the value of $8.87337441 \times 10^{-10}$ kgm/s^2·m^2 from which electric permittivity derived.

So we calculate the density of the vacuum to be:

$$\rho = E/c^2 \approx 9.86 \times 10^{-27}\ \text{kg}/\text{m}^3$$

This value corresponds closely to the cosmological critical density and supports the idea that the vacuum itself has an intrinsic density derived from its elastic and electromagnetic properties.

7. Electric Permittivity and Vacuum Compressibility

One of the ways to describe the vacuum is through its electric permittivity (ϵ_0) and related constants, which provide a path to calculating the density of the vacuum [20].

The speed of light in a vacuum, c, is related to both the electric permittivity (ϵ_0) and magnetic permeability (μ_0) by the equation:

$$c = 1/\epsilon_0 \mu_0$$

This equation highlights that the speed of light is not just an abstract concept but is directly dependent on the vacuum's ability to support electric and magnetic fields. The permittivity ϵ_0 governs how electric fields are permitted through space, while permeability μ_0 governs the vacuum's response to magnetic fields. Together, these constants define the properties of light and how it propagates through the vacuum.

To go a step further, we can relate the elasticity of the vacuum (measured by its bulk modulus) to its density. The bulk modulus (K) is a measure of a material's resistance to compression and is defined in the context of the vacuum by its interaction with pressure. For the vacuum, the speed of light can be used as a substitute for the speed of sound in classical mechanics, where:

$$v = \left(K/\rho\right)^{1/2}$$

In this context, the speed of light c is analogous to the speed of sound, and the bulk modulus K represents the vacuum's elasticity. We can then rewrite the equation for the vacuum's bulk modulus as:

$$K = \rho c^2$$

Now, let's connect the bulk modulus with the vacuum's permittivity and permeability. Substituting the expression for the speed of light into the bulk modulus equation gives:

$$K = \rho / \epsilon_0 \mu_0$$

To solve the density ρ, we rearrange the equation:

$$\rho = \epsilon_0 \mu_0 K$$

This equation shows that the density of the vacuum can be calculated using three constants:

- ϵ_0 (electric permittivity): 8.854×10^{-12} F/m
- μ_0 (magnetic permeability): $4\pi \times 10^{-7}$ N/A^2
- K (bulk modulus): 8.55×10^{-10} Pa

The calculated value:

$$\rho \approx 9.51 \times 10^{-27}\ \text{kg/m}^3$$

The calculation of the vacuum's density through its electric permittivity and related constants provides a way to bridge the gap between the mechanical and electromagnetic properties of the vacuum.

8. *G* Constant as an Expression of Drag Force of the Omniom Vacuum

The constant G is an expression of the resistance encountered by the gravitational force in the vacuum according to the formula:

$$P = 1/2\, \rho c^2 C_D, \text{ [21]}$$

where:

- P is the pressure gradient generated by drag = $6.67383255 \times 10^{-11}$ kg/m·s^2 from which derived the constant G

  C_D = between 0.1 and 0.2 ≈ 0.156 (drag coefficient),
- $c = 3 \times 10^8$ m/s.

The drag force per specific volume rate can be equated to the gravitational constant G when considering the vacuum as a fluid-like medium. Constant G, which has units of m^3·kg^{-1}·s^{-2} represents a kind of "drag" force or resistance that gravity must overcome to move density of vacuum. The rate of displacement of a specific volume of vacuum per kilogram per second which has m^3·kg^{-1}·s^{-1} units is proportional to the pressure or force needed to move the weight of that volume per second, which is effectively the drag force overtime which has the same G constant units.

The drag pressure of the vacuum is constant because it is derived through conservation of momentum using density and velocity.

We need to solve for ρ, we get:

$$\rho = 2P / c^2 C_D \approx 9.51 \times 10^{-27}\ \text{kg/m}^3$$

This calculated vacuum density matches closely with cosmological estimates, further supporting the interpretation of G as a consequence of vacuum drag properties.

The drag pressure of the vacuum remains constant, as it is fundamentally derived from the conservation of momentum—dependent only on the vacuum's density and the speed of light. This insight provides a hydrodynamic interpretation of gravity, reframing G not as an arbitrary constant but as an emergent property of the dynamic vacuum medium.

9. Magnetic Permeability Constant and Viscosity of the Omniom Vacuum

The magnetic permeability constant (μ_0) is a fundamental property of the vacuum that influences how magnetic fields propagate through it. The magnetic constant is similarly related to the physical structure and properties of the Omniom vacuum, which can be defined in terms of its viscosity, density, and velocity [22].

In classical electromagnetism, magnetic permeability indicates the degree of opposition to the magnetic field which passes through the vacuum this is denoted as

$$\mu_0 = 1.206572 \times 10^{-6}\ \mathrm{N \cdot s / A^2}\ .$$

When an electron moves through the vacuum, its momentum is influenced by both its mechanical properties and the electromagnetic properties of the Omniom vacuum. In particular, the vacuum's magnetic permeability plays a critical role in how magnetic fields propagate and interact with the electron's motion.

Using Omniom vacuum, this resistance lowers the velocity of the particles in the vacuum and thus there is a relation between the magnetic permeability and density of the vacuum.

Momentum, in classical mechanics, is the product of an object's mass and velocity ($P = mv$). For rotating electron vortex is influenced by the shear stress of the Omniom vacuum, its momentum is diminished by:

$$P = \rho c / \lambda$$

where:

- P is the momentum affected by Omniom vacuum,
- ρ is the density of the Omniom vacuum,
- c is the speed of light ($c \approx 3 \times 10^8$ m/s),
- λ is the Compton wavelength of the electron ($\lambda = 2.426310235 \times 10^{-12}$ m).

The value for P (diminished momentum) is given as:

$$P = 1.206572 \times 10^{-6}\ \mathrm{kg / m^2 \cdot s}$$

This value corresponds to the magnetic field momentum of the rotating electron as it interacts with the Omniom vacuum. The combined influence of the vacuum's density, the speed of light, and the Compton wavelength determines this specific value of diminished momentum. The flowing electron (current) in the vacuum plays a central role in generating magnetic fields and interacts with Omniom vacuum and influence further the magnetic field momentum. As the electron moves through the vacuum, its momentum is diminished by the interaction with the Omniom vacuum, and this interaction is governed by the vacuum's magnetic permeability.

The rate of change of the magnetic momentum over time is expressed as: P/tI^2 .

The current is squared in the expression P/tI^2 because the effects of current on the system's energy, magnetic field strength, and electromagnetic interactions typically scale with I^2. This quadratic relationship reflects how the current generates more powerful fields and energy as it increases, and thus how it influences the system's momentum and dynamics.

Therefore, the diminished momentum of the magnetic field would have the final units of $kg\cdot m/s^2\cdot A^2$ which correspond to the magnetic permeability units. Therefore

$$P/tI^2 = \mu_0 = 1.206572\times10^{-6}\ \mathrm{N\cdot s/A^2}$$

This equation shows that the diminished momentum P per unit time t and per squared current I^2 equals the magnetic permeability constant (μ_0), which has units of $N\cdot s/A^2$.

The calculated density of the Omniom vacuum replace P with $P = \rho c/\lambda$.

Then the density can be calculated to be:

$$\rho = P\lambda/c \approx 9.76\times10^{-27}\ \mathrm{kg/m^3}$$

In conclusion, the density of the Omniom vacuum, calculated from fundamental constants such as the speed of light, vacuum permittivity, magnetic permeability, and the gravitational constant, consistently falls within the range of approximately 9.51×10^{-27} to 9.86×10^{-27}.

10. The Density of the Singularity

The Omniom is the primordial vacuum with a static and stable density made of nonrotating soap bubbles like named Omnicles. With the Big Bang the temperature, density and pressure increased dramatically leading to symmetry break and creating a pressure gradient from the center of the burst of the Big Bang to the periphery like an explosion pressure. The expansion front wave density is made of three different densities, dark matter, matter density and dark energy density. The universe is defined as the part of the expanding wave.

The main point that differentiates our theory from previous ones is that outside the universe is full of limitless eternal static Omniom vacuum where there is no particle, radiation no space or time. The expansion wave after the Big Bang took place in the Omniom vacuum container in which a gradient pressure was formed between the expanding momentum and the Omniom vacuum density. When the expanding momentum will be equal to the static Omniom density at the edge of the universe the expanding wave will stop.

The formatting universe is made of three different densities: radiation density, matter density, and vacuum density. As the universe expands, the vacuum density (dark energy) decreases relative to the Omniom vacuum density. However, the formation of dark matter and matter compensates for this drop, ensuring that the overall density remains balanced. This equilibrium is crucial for maintaining the critical density, which determines the universe's fate—whether it will continue expanding indefinitely or eventually reach a stable state.

Prior to Big Bang, the vacuum was stable, that is, did not have any dynamics or disturbance. However, the very first burst of the Big Bang which was a violent explosion changed this stability abruptly to form singularity.

The Big Bang singularity is defined as the moment at the inception of the universe. According to general relativity, the universe began from a state of infinite density and temperature.

During the early universe, the temperature was related to the time in the radiation-dominated era. The temperature of the universe at very early times can be estimated using the following equation:

$$T(t) = 10^{10}\,Kt/(t)^{1/2}$$

where:

- $T(t)$ is the temperature at time t.
- t is the time after the Big Bang in seconds.

For example:

- At $t = 1$ second after the Big Bang, the temperature is roughly 10^{10}.
- At $t = 10^{-12}$ seconds, the temperature would be much higher, close to 10^{15} K.
- At $t = 6.82 \times 10^{-24}$ seconds the time when the temperature was around 3.83×10^{21} K.
- At $t = 10^{-43}$ seconds after the Big Bang, the temperature was approximately 3.16×10^{31} K.

At the time of 10^{-43} seconds the density of the thermal bath of relativistic particles can be calculated according to the equation:

$$\rho = \left(\pi^2/15\right)\left(k^B T/\hbar c\right)^4$$

where:

- $g = 1$ g (effective degrees of freedom).
- $k^B \approx 1.38 \times 10^{-23}$ J/K (Boltzmann constant).
- $T = 3.16 \times 10^{31}$ K (Planck temperature).
- $\hbar \approx 1.05 \times 10^{-34}$ J·s.
- $c \approx 3 \times 10^8$ m/s.

In the early universe that came immediately after the Big Bang but before the formation of ordinary particles, the g effective number of relativistic degrees of freedom is generally high around 100. This value includes photons, quarks and leptons, which are the identical contributions from all the particles in the Standard Model that were existent at that time and were relativistic.

However, during the very critical stage of the universe known as the pre-Planck epoch where g is given by 10^{-43} seconds after the Big Bang $g \approx 1$ becomes quite reasonable. At this period the universe might have been primarily a single or a very small number of quantum fields as opposed to a whole lot of particles. The state of the universe was such that energy density was quite low due to very few differentiating factors which approximated lower values of *g*.

With the expansion and cooling of the universe, there was a symmetrical breaking leading to formation of particles and the value of gg rose rapidly to the value of approximately 100, illustrating the increasing complexity of the content addressed by the universe.

The calculated density would be:

$$\rho \approx 2.42 \times 10^{136}\ \mathrm{kg/m^3}$$

However, the density at the moment of singularity known as Planck density is estimated by calculation to be:

$$\rho_P = m_P / l_P^3 \approx 5.155 \times 10^{96}\ \mathrm{kg/m^3}$$

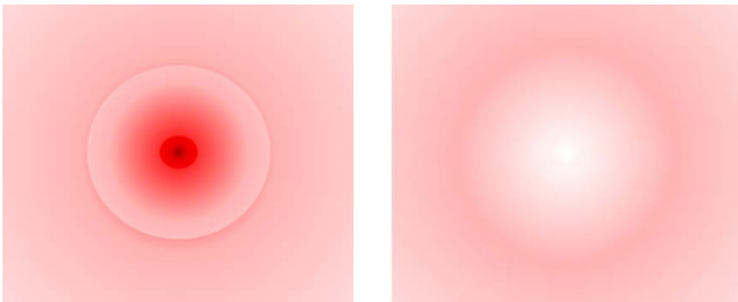
this density was at a time $t = 6.82 \times 10^{-24}$ seconds.

The pressure at this density can be calculated using the equation of state for radiation in relativistic systems, which relates pressure and energy density:

$$P = \rho/3$$

The pressure at the density $\rho = 5.155 \times 10^{96}$ kg/m^3 is approximately 1.72×10^{96} Pa.

This high pressure arises due to the extreme density of energy at such temperatures, pushing against surrounding Omniom vacuum leading to the expansion of the universe (**Figure 1**).



(a) (b)

Figure 1. (a) The Planck density in the center, expanded in the dark energy and led to decrease its density relative to surrounding Omniom vacuum. (b) The density of the dark energy at the end of the expansion, where the dark energy density will be less than the surrounding dark energy density which will lead to the contraction of big crunch.

The density of the universe at the moment of the Big Bang, known as the Planck density, was vastly different from the Omniom vacuum density that was prior to the Big Bang.

At the singularity, the density reached an extreme value of

$$\rho_P = 5.155 \times 10^{96}\ \mathrm{kg/m^3}$$

and a pressure of

$$P = 1.72 \times 10^{96}\ \mathrm{Pa},$$

while the Omniom vacuum density, at the moment of the Big Bang was

$$\rho = 9.51\times10^{-27}$$

with a pressure of

$$P = 3.17\times10^{-27}\ \text{Pa}\ .$$

This vast pressure gradient between the singularity and the surrounding vacuum initiated the rapid expansion of the universe.

The Big Bang marked a pivotal transition from a static Omniom vacuum state to a dynamic singularity characterized by infinite density and temperature. This transition triggered the emergence of spacetime, radiation, and matter. The Omniom vacuum subsequently evolved into expanding dark energy, possessing a lower density than its original state. Thus, the Omniom vacuum can be envisioned as the infinite container in which the singularity occurred, giving rise to the expanding universe. As the universe expanded, part of this vacuum condensed into matter and dark matter, while the remainder persisted as dark energy.

To better understand how the universe began its expansion from the singularity, we can calculate the resulting dynamics using the extreme pressure difference between the Planck state and the surrounding Omniom vacuum:

1) Pressure Gradient

$$\Delta P = P_P - P_V \approx 1.72\times10^{96}\ \text{Pa}$$

(The vacuum pressure is negligible on this scale.)

2) Estimate of Expansion Acceleration

Using Newton's second law or the fluid momentum equation:

$$a = \Delta P/\rho$$

Substituting the vacuum density:

$$a = \left(1.72\times10^{96}\right)/\left(9.51\times10^{-27}\right) \approx 1.81\times10^{122}\ \text{m/s}^2$$

3) Estimating Initial Expansion Velocity

Assuming this acceleration acted over Planck time:

$$t_P \approx 5.39\times10^{-44}\ \text{s}$$

Then the expansion velocity would be:

$$v = a\times t_P = \left(1.81\times10^{122}\right)\times\left(5.39\times10^{-44}\right) \approx 9.76\times10^{78}\ \text{m/s}$$

This velocity exceeds the speed of light, but since it describes the expansion of space itself (rather than motion through space), it does not violate the theory of relativity.

The calculated pressure gradient between the singularity and the Omniom vacuum led to an estimated acceleration of 1.81×10^{122} m/s^2 and an initial expansion velocity of approximately 10^{78} m/s. This supports inflationary theory and highlights the importance of vacuum properties—particularly elasticity and density—in governing cosmic expansion.

The key distinction between the Omniom vacuum and dark energy lies in their densities—dark energy exhibits a lower density. As the Omniom vacuum expands, it transforms into dark energy, which continues to drive the accelerated expansion of the universe.

This new perspective offers valuable insights into the origin of matter and dark matter, proposing that the Omniom vacuum played a central role in shaping the universe's structure. As expansion progressed, portions of the vacuum condensed into matter, while the remainder became dark energy. This dynamic interaction between vacuum and matter opens new avenues for understanding the nature of dark energy, dark matter, and the evolution of the cosmos.

11. Cosmological Constant as a Measure of Dark Energy Density

One of the most crucial concepts in explaining the accelerated expansion of the universe is the cosmological constant (Λ). It accounts for the energy density of empty space in the present era, often referred to as vacuum energy or dark energy. The dark energy density, denoted as ρ_Λ, is proportional to the cosmological constant and can be expressed as:

$$\Lambda = 8\pi G\rho_\Lambda / c^2$$

where:

- Λ is the cosmological constant,
- c is the speed of light ($c \approx 3 \times 10^8$) m/s,
- G is the gravitational constant ($G \approx 6.67430 \times 10^{-11}$ $\text{m}^3\cdot\text{kg}^{-1}\cdot\text{s}^{-2}$).

The vacuum energy density ρ_Λ can be obtained from cosmological observations, especially through data on the accelerated expansion of the universe.

Observational data, particularly from studies of distant supernovae, suggest a value for the cosmological constant of approximately [23]:

$$\Lambda = 1.1 \times 10^{-52}\ \text{m}^{-2}$$

The value is based on recent measurements of vacuum energy density, ρ_{vac} = 5.96×10^{-27} kg/m^3 = 5.3566×10^{-10} J/m^3 = 3.35 GeV/m^3.

Currently, this is a lower vacuum density than the primordial Omniom vacuum density which was seen in the universe before the Big Bang. This change can be comprehended by appreciating that some of the initial vacuum density of the universe has in the course of time been transformed into matter and which has very much changed the mature structure as well as the evolution of the universe.

Therefore, the current density of the black energy is estimated to be around $\rho_\Lambda \approx 5.91 \times 10^{-27}$ kg/m^3. In contrast, the density of the vacuum surrounding the universe, known as the Omniom vacuum, is higher at approximately 9.51×10^{-27} kg/m^3.

12. The Density Evolution

Before the Big Bang, the universe existed in a state referred to as the Omniom vacuum. This primordial vacuum had a stable density of approximately 9.51×10^{-27} kg/m^3. The Omniom vacuum is conceptualized as the infinite, static container from which the universe emerged. It was filled with energy, and though seemingly stable, it set the stage for the immense event known as the Big Bang.

At the moment of the Big Bang, the density of the universe reached an extraordinary value, approximated at 10^{96} kg/m^3. This event can be thought of as a spark that initiated the rapid expansion of space-time, causing the universe to evolve from a state of extreme density and temperature to one of expansion and cooling. This expansion transformed the Omniom vacuum into what we now understand as dark energy.

As the universe expanded, the density of the Omniom vacuum decreased, eventually settling into what we now observe as the density of dark energy, currently estimated at 5.9×10^{-27} kg/m^3. This decrease in density reflects the dramatic change in the structure and scale of the universe from the singularity to its present state. The decline in density also explains why the cosmological constant, which depends on the energy density of the vacuum, is not truly a constant.

The cosmological constant (Λ) is a term introduced by Einstein in his equations of general relativity to represent the energy density of empty space, or vacuum energy. While often viewed as a fixed value, in reality, the cosmological constant is tied to the density of dark energy, which changes as the universe expands. As the universe grows, the density of dark energy decreases, leading to a gradual shift in the value of Λ.

This decrease in dark energy density mirrors the overall expansion of the universe: as the universe grows, the total volume of space increases, causing the density of energy to spread out. Although dark energy is often described as a constant force driving the expansion, its density slowly decreases, reflecting the dynamism of the universe.

To describe the density evolution of the universe from the singularity to today, we can model how the density of the universe decreases over time as it expands. The universe's expansion causes its density to decrease because the total amount of matter and energy spreads out over an increasing volume.

The curve of density as a function of time can be derived based on several factors:

1) The initial density at the singularity (ρ_{initial}).

2) The current density of dark energy (ρ_{current}).

3) The age of the universe (around 13.8 billion years or 4.35×10^{17}).

4) The cosmological expansion governed by general relativity, primarily through the Friedmann equations, which describe the universe's expansion.

In a basic cosmological model, the density of the universe evolves according to the scale factor $a(t)$, which describes how the universe's size changes over time. The density of the universe, particularly in its different components (matter, radiation, dark energy), decreases at different rates depending on the dominant form of energy.

The density of matter decreases as the universe expands because the volume of space increases. The matter density is inversely proportional to the cube of the scale factor, so:

$$\rho_{\text{matter}}(t) \propto 1/a(t)^3$$

During the radiation-dominated era (very early universe), radiation density falls off faster due to the additional effect of redshift, where radiation loses energy as the universe expands:

$$P_{\text{radiation}}(t) \propto 1/a(t)^4$$

The density of dark energy decreased very slightly remains roughly constant over time because it is thought to represent a constant energy density per unit volume (**Figure 2**).

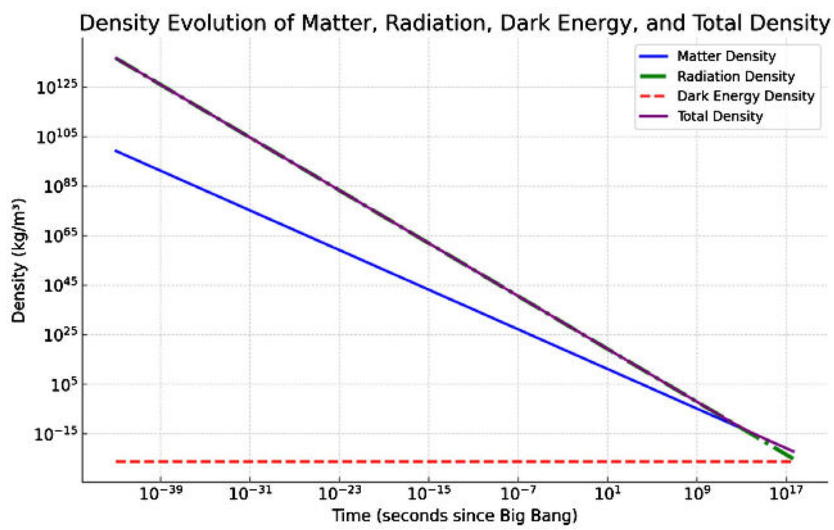


Figure 2. The evolution of matter density (blue), radiation density (green), Omniom vacuum to dark energy density (red), and the total density (purple). You can clearly see how radiation dominated in the early universe, with matter taking over later, and finally, dark energy becoming dominant in the present era. The total density curve reflects the combined contributions of all these components.

13. Hydrodynamic Interpretation of Cosmic Expansion

The dynamics of the early universe can be effectively described by hydrodynamic laws if we interpret the vacuum as a compressible and elastic medium, referred to here as the Omniom. When both the vacuum density (ρ) and the acceleration of expansion (a) are known, it becomes possible to describe the expansion as a fluid-like flow driven by pressure gradients and governed by momentum conservation.

In fluid dynamics, the Euler equation for a compressible, inviscid fluid is given by:

$$D\vec{v}/Dt = -1/\rho \cdot \nabla P$$

here, $\vec{v}$ is the velocity field (expansion velocity), $D\vec{v}/Dt$ is the material derivative (the rate of change of velocity in time and space), ∇P is the pressure gradient, and ρ is the fluid (vacuum) density.

Under the assumption of isotropic and spherically symmetric expansion, this equation reduces to:

$$a = \mathrm{d}v/\mathrm{d}t = -1/\rho \cdot \mathrm{d}P/\mathrm{d}r$$

If both the acceleration a and the density ρ are known, the pressure gradient driving the expansion is:

$$\mathrm{d}P/\mathrm{d}r = -\rho \cdot a$$

If the vacuum behaves like a perfect fluid, we can describe its pressure using an equation of state:

$$P = w \cdot \rho \cdot c^2$$

where w is the equation-of-state parameter:

- $w = 0$ corresponds to pressureless dust (matter),
- $w = 1/3$ corresponds to radiation,
- $w = -1$ corresponds to a cosmological constant or dark energy.

This formulation allows pressure P to be computed directly from the vacuum density ρ.

The continuity equation, representing conservation of energy in an expanding universe, is expressed as:

$$\mathrm{d}\rho/\mathrm{d}t + \rho \nabla \cdot \vec{v} = 0$$

For a homogeneous and isotropic universe with a time-dependent scale factor $a(t)$, it simplifies to:

$$\mathrm{d}\rho/\mathrm{d}t + 3\left(\dot{a}/a\right) \cdot \rho = 0$$

This equation captures how the density of the universe evolves as a function of its expansion rate.

Application to the Omniom Vacuum Model

Assuming a vacuum density of:

$$\rho = 9.51 \times 10^{-27}\ \mathrm{kg/m^3}$$

and an expansion acceleration of:

$$a = 1.81 \times 10^{122}\ \mathrm{m/s^2}$$

we can compute the resulting pressure gradient:

$$\nabla P = -\rho \cdot a = -\left(9.51 \times 10^{-27}\right) \times \left(1.81 \times 10^{122}\right) \approx -1.72 \times 10^{96}\ \mathrm{Pa/m}$$

This value closely aligns with the calculated difference between the Planck pressure and the initial vacuum pressure, validating the hydrodynamic framework.

Within the Omniom model, the vacuum behaves as a coherent superfluid-like medium. The observed expansion of the universe is not simply geometric but results from hydrodynamic forces generated by a pressure gradient at the origin. This pressure gradient, interpreted as a vacuum drag force, governs the rate of cosmic expansion through momentum conservation and compressibility. This hydrodynamic description offers a bridge between quantum vacuum structure, gravity, and large-scale cosmic evolution.

14. Discussion

The cosmological constant problem, often referred to as the "vacuum catastrophe", has long perplexed physicists. It stems from the staggering difference between the vacuum energy predicted by quantum field theory and the much smaller value inferred from the universe's expansion. Quantum field theory estimates a vacuum energy density on the order of 10^{96} kg/m^3, while cosmological observations suggest a value as low as 9.5×10^{-27} kg/m^3. This mismatch by 120 orders of magnitude highlights a fundamental gap in our understanding of the universe, particularly when it comes to how energy behaves in the vast emptiness of space.

However, there may be a simple yet profound way to reconcile these vastly different values, and it hinges on distinguishing between two critical phases of the universe: the Omniom vacuum density that existed before the Big Bang, and the Planck density, which manifested immediately afterward. This distinction could hold the key to unlocking the solution to the cosmological constant problem.

The Omniom vacuum is conceptualized as a perfect, stable state that existed before the universe's birth in the Big Bang where space and time did not exist. In this pre-Big Bang era, the Omniom vacuum had no fluctuations, no particles, and no motion—just a calm, inert, static field with a very low energy density, approximately 9.5×10^{-27} kg/m^3. This stable state existed without disturbance or dynamics. It was only with the violent spark of the Big Bang that this vacuum state was disrupted. The energy and matter of the universe erupted into being, and what was once a smooth, static vacuum transformed into a chaotic, high-energy environment.

In contrast, the Planck density is vastly different. It appeared immediately after the Big Bang, around 10^{-44} seconds into the universe's existence, when the universe was filled with incredibly hot, dense radiation and energy fields and the appearance of space and time. The Planck density, calculated as roughly 5.155×10^{96} kg/m^3, represents the highest possible density in the universe—one governed by quantum gravitational effects, where all known forces, including gravity, were unified. This density didn't emerge in the pre-Big Bang vacuum but rather as a consequence of the Big Bang itself, when energy and quantum fluctuations began to dominate the nascent universe.

It's important to emphasize that the Planck density and the vacuum energy density serve different roles in cosmology. The Planck density describes the extreme energy concentration immediately following the Big Bang, when the universe was incredibly small, hot, and dense. Quantum fluctuations and virtual particles abounded, rapidly forming and annihilating in the chaotic conditions of the early universe. On the other hand, the Omniom vacuum energy density reflects the steady, persistent energy present in empty space today, also known as the cosmological constant or dark energy, which is driving the accelerated expansion of the universe.

In this proposed framework, the solution to the cosmological constant problem lies in understanding that the Omniom vacuum density and the Planck density are not interchangeable. The Omniom vacuum existed in the absence of space-time, matter, radiation, or fluctuations. It was a static, low-energy field that remained undisturbed until the Big Bang unleashed an enormous amount of energy. The Planck density, which appeared after the Big Bang, represented the chaotic and dynamic energy state of the universe in its earliest moments. The universe transitioned from a state of low vacuum energy (the Omniom vacuum) to one of extreme density (the Planck epoch) during the Big Bang.

As the universe expanded and cooled, the energy density dropped dramatically. The transition between these vastly different energy densities—the low Omniom vacuum before the Big Bang and the high Planck density just after—may help explain why we observe such a low vacuum energy density today. This rapid drop in energy density, caused by the expansion of space, allowed the universe to cool and form structures, such as galaxies and stars, while also reducing the influence of quantum fluctuations.

Therefore, the massive difference in energy densities may not be a catastrophe after all, but a natural consequence of the universe's evolution from an undisturbed, pre-Big Bang vacuum to the dynamic, dense universe that followed. This explanation suggests that the vacuum energy we observe today is simply a remnant of the initial state, a quiet echo of the static Omniom vacuum that existed before the Big Bang. The Planck density, on the other hand, is tied to the extreme conditions of the universe's birth and should not be conflated with the long-lasting, low-energy vacuum that now dominates the universe.

By recognizing that the energy density of the Omniom vacuum and the Planck density arise from different phases of the universe's history, we may have a path forward in resolving the cosmological constant problem. Instead of searching for ways to reconcile quantum field theory's predictions with the vacuum energy we observe today, we can focus on understanding how the early universe's transition from a no-energy vacuum to a high-density state shaped the evolution of space-time, eventually giving rise to the cosmological constant as we see it now.

15. Conclusions

The cosmological constant problem, often referred to as the "vacuum catastrophe", highlights a significant discrepancy between the observed vacuum energy density and the much larger values predicted by quantum field theory. This paper introduces the concept of the Omniom vacuum—a primordial state with a density of approximately 9.51×10^{-27} kg/m^3—as the static, stable backdrop from which the universe emerged. In contrast, the singularity at the moment of the Big Bang exhibited an extraordinary density of around 5.155×10^{96} kg/m^3, marking a phase of extreme compression and energy concentration.

The transition from the Omniom vacuum to the singularity was a critical point in the universe's evolution, leading to the rapid expansion and cooling of space-time. As the universe expanded, the density of the Omniom vacuum decreased and transformed into what we now understand as dark energy, which continues to drive the universe's accelerated expansion. Dark energy, however, has a slightly lower density of approximately 5.91×10^{-27} kg/m^3 relative to Omniom vacuum density, which has stabilized the large-scale structure of the universe. This difference in density is attributed to the transformation of part of the Omniom vacuum into dark matter and dark energy, and the overall expansion of the universe.

Notably, the calculation of cosmological density relying on critical density equation and Hubble's law and the vacuum density, relying on fundamental constants such as the speed of light, vacuum permittivity, and the gravitational constant, resulted in consistent values. This consistency further supports the idea that the vacuum density observed today is a remnant of the Omniom vacuum, slightly diminished as a result of cosmic expansion and matter formation. The cosmological constant (Λ) is thus an expression of the dark energy density, which is slightly less than the Omniom vacuum density due to the ongoing expansion of the universe and the conversion of some of the primordial vacuum into matter and dark matter.

By distinguishing between the pre-Big Bang Omniom vacuum, the high-density singularity, and the current state of dark energy, this framework offers a fresh perspective on resolving the cosmological constant problem. It suggests that the enormous difference in energy densities is not a "catastrophe" but rather a natural consequence of the universe's transition through these phases. The singularity's extreme density eventually gave way to the current state of dark energy through the universe's expansion, cooling, and structural formation.

Future research should focus on investigating the properties of the Omniom vacuum and the high-density singularity to provide deeper insights into the universe's formation and evolution. While significant progress has been made in understanding the universe's expansion and structure post-Big Bang, a complete theory must also explain the moment of the Big Bang itself. By developing new theoretical models and refining experimental methods, we can continue unravelling the mysteries of the universe's origins, confirming or refining predictions of a comprehensive cosmological theory. Only then will we fully comprehend how the universe emerged from the initial burst and evolved into its current state.

Cosmological observations—particularly those related to dark energy and the universe's expansion—alongside advancements in quantum theory, will be crucial in validating the proposed model and resolving one of the most profound mysteries in modern physics.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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