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The Asymmetric Time, Key to a New Standard Model of Cosmology

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Abstract

In order to resolve some current problems in cosmology, time is relativized once again beyond the framework of the theory of relativity—specifically, in such a way that it ran faster in the past than it does today and will run slower and slower in the future. This asymmeltry of time follows as a logical conclusion from the General Theory of Relativity and from Einstein's recommendation: < one can use the principle of the constancy of the speed of light in a vacuum to complete the definition of time. > With respect to the here-and-now time t, the speed of light is then time-dependent. This leads to a paradigm shift and thereby resolves many fundamental problems in physics, particularly in cosmology. The individual steps leading to Asymmetric Time and the consequences arising from them are outlined in the following discussion.

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The Asymmetric Time Hypothesis (ATH)

The Einstein-de Sitter universc was long considered the standard model of cosmology. It was later abandoned when measurements of Type la supernovae led to the conclusion that the universe is expanding at an accelerating rate. Another observational finding was that stars rotate around the center of their galaxies faster than Newtonian theory allows. Instead of trying to reconcile the empirical findings with the Einstein-de Sitter model, researchers took the easier route and simply introduced two new concepts - dark matter and dark energy - mysterious substances that are ultimately nothing more than placeholders for unknown physics. Today, they are an essential component of the current standard cosmological model, the ACDM model (Λ =

cosmological constant, CDM = Cold Dark Matter). Yet Einstein had already shown the correct path. For the Einstein-de Sitter universe ($\Lambda = 0$, $k = 0$), he formulated the equation[1]: $\varkappa\varrho/3 - h^2 = 0$ (see appendix for the meaning of the symbols)

$$2\,GM/Rc^2 = 1 \quad (1)$$

This is inconsistent with current knowledge, because it implies that G, M, and c are constant and $R \sim t^{2/3}$, From Eq. (1), with GM = constant and $R \sim t^{2/3}$,

$$c \sim t^{-1/3} \sim \dot{R} = dR/dt \quad (2)$$

we obtain a time-dependent speed of light proportional to the expansion rate of the flat universe. Using Einstein's coupling constant $\varkappa = 8\pi G/c^2$ = constant, we further obtain

$$G \sim t^{-2/3} \quad (3)$$

and from the law of conservation of energy $E = Mc^2$ = constant, we finally obtain

$$M \sim R \sim t^{2/3} \quad (4)$$

Equations (2) through (4) are compatible with Equation (1), but they all contradict the current state of knowledge. Equation (2) is the most provocative, as it directly violates Einstein's axiom: < The speed of light is a universal constant >. The statemeht c = constant means that the measured numerical value of ¢ must always be the same at every location and at every time. The problem now is to reconcile this requirement with relation (2). This can be achieved by following Einstein's recommendation and introducing a time 7 that varies proportionally to the world radius.

For the Einstein—de Sitter universe, we then obtain

$$\tau \sim R \sim t^{2/3} \quad (5)$$

and the relation consistent with (2)

$$d\tau/dt \approx \Delta t/\Delta t \sim t^{-1/3} \sim \dot{R} = dR/dt \sim c \quad (6)$$

In fact, pendulum clocks and atomic clocks display precisely this asymmetric time t when they tick according to the laws of ATH. Measured with such clocks, the speed of light is then a constant [3]:

$$c(\tau) \sim dR/d\tau = \text{constant} \quad (7)$$

The time scale would thus depend not only on relative velocity (SRT) and gravitational potential (ART), but also on time itself (ATH). Figure 1 compares these dependencies. As can be seen from this,

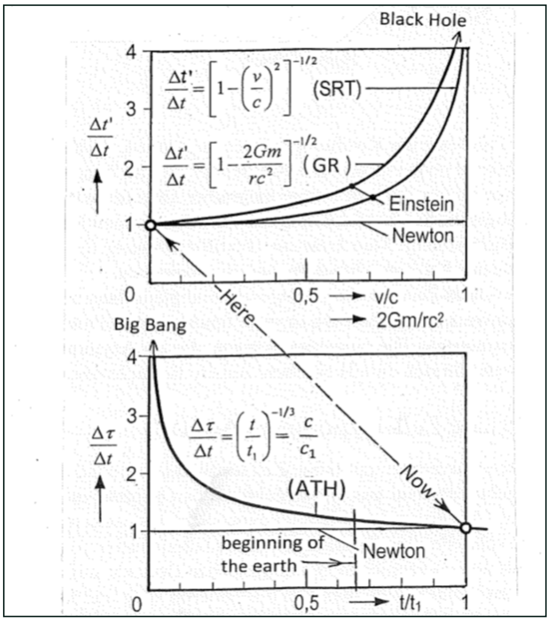

Figure 1: Times according to SRT, GRT, and ATH (t_1 = today)

Asymmetric time is the rate at which cosmic evolution changes ($\Delta \tau / \Delta t = (t/t_1)^{-1/3}) = c/c_1$). Relative to the here-and-now time interval At, the Big Bang recedes into the infinite past. Stephen Hawking would agree with this as well[4]: < According to the strong version of cosmic censorship, in a realistic solution, singularities are always entirely in the future (such as the singularities of gravitational collapse) or entirely in the past, such as the Big Bang. >
Note: In order to compare and interpret events that took place at different times, the physical quantities must be referenced to the same point in time. For the ATH, this is the here-and-now

The Spacetime of the Universe

In the theory of relativity, space and time were combined into a four-dimensional spacetime continuum

$$dx_1^{\,2} + dx_2^{\,2} + dx_3^{\,3} + dx_4^{\,4} = 0 \quad (8)$$

(x_1, x_2, x_3 = spatial coordinates, x_4 = ict = imaginary time coordinate)
Applied to the flat expanding universe ($R \sim t^{2/3}$, $dR/dt \sim t^{-1/3}$, $r \sim R$), the relationship

$$dr^2 = (cdt)^2 \quad (9)$$

or

$$c \sim dr/dt \sim t^{-1/3} \sim d\tau/dt \quad (10)$$

This result is identical to equation (6) and also answers R.A. Muller's question: [5] < If we imagine the universe as four-dimensional spacetime, why should it expand only spatially and not also temporally? > This is precisely what the ATH requires. It replaces the stationary spacetime of SRT with a spacetime that refers to real space ($r \sim t^{2/3}$) and asymmetric time ($\tau \sim {}^{2/3}$). According to the ATH, space (R), time (τ), and matter (M) evolve according to identical laws ($R \sim \tau \sim M \sim t^{2/3}$). Heinrich Pas arrives at the same conclusion from a quantum physics perspective.[2] < Personally, I am firmly convinced that space, time, and matter are very closely linked, in a fundamental and principled way - that space, time, and matter ultimately arise together from an underlying quantum reality. >

Long-standing Problems with the Big Bang Theory

The Horizon Problem

This problem stems from the fact that scientists could not explain why the cosmic microwave background (CMB) is so uniform, as satellite measurements show. To solve this problem, the theory of inflation was developed. It states that shortly (10^{-35}seconds) after the Big Bang, the universe is thought to have expanded abruptly by a factor of 10^{50}, thereby becoming isotropic on a large scale. The ATH offers a much more plausible explanation here. According to this theory, light signals in the early universe were fast enough ($c \sim t^{-1/3}$) to enable the high isotropy of the CMB.

The Problem of Flatness

Attempts were also made to solve this problem using the theory of inflation. Due to the extreme expansion, the universe is said to have become almost exactly flat. However, inflationary theory provides no answer to the question of how the unstable state of a flat space could have been maintained to this day. On this, J. Magueijo[6] notes: < In fact, it appears as though the universe has been performing this delicate balancing act for 15 billion years—a process that is highly improbable, if not simply impossible. That is why we speak of the flatness problem, the second of the Big Bang puzzles. >

The AZH explains why the flatness is preserved in the long term as follows: If the universe expands faster than Equation (1) predicts, the gravitational constant G increases, which slows down the expansion. If it expands more slowly, G decreases and the expansion accelerate. The AZH is therefore not only more elegant than the theory of inflation, but also more meaningful.

The Problem of Galaxy Formation and the Formation of Supermassive Black Holes in the Early Universe

The problem is that, according to the Big Bang theory, there has not been enough time for the concentrations of matter observable today (stars, galaxies, black holes, galaxy clusters) to form. However, the AZH also offers an explanation for this. It states that the "event velocity" in the early universe was many times higher than it is today ($c \sim t^{-1/3}$). Furthermore, the gravitational constant was also much larger than it is now ($G \sim t^{-2/3}$). This could not only explain the images from the James Webb Space Telescope but also-answer the question of why supermassive black holes with several billion solar masses already existed in the early universe and why they become larger the further back in time we look.

The Problem of the Age of the Universe

Because the AZH universe has no temporal beginning ($\Delta t/\Delta t \sim t'^{-1/3}$), this problem does not exist. Note: The following explanations of astronomical observations all refer to the here-and now time t and a universe age of 13.8×10^9 years.

Cosmic Energy Balance

Many cosmologists assume that the total energy in the universe is exactly zero. They postulate a negative binding energy that precisely balances the positive energy (matter and radiation). However, it is difficult to understand why gravitational binding energy should be negative.

After all, it increases the farther apart two masses are. When these masses attract each other gravitationally and the smaller one is forced into a circular orbit around the larger one - like a planet around a central star - the former gravitational energy has been converted into an equal amount of kinetic energy, albeit with higher entropy, as can be demonstrated by the Sun—Earth or Barth-Moon systems.[3] The original gravitational energy must therefore have been positive. In the decelerating expansion of the universe, the opposite occurs. Kinetic energy is constantly being converted into (positive) gravitational potential energy. Incidentally, Einstein also grappled with the concept of "negative energy" after he had removed the cosmological constant Λ—which he himself had originally introduced and which can be understood as a synonym for negative energy or negative pressure—from his field equations. The result of his considerations was:[1] < The problem with this solution (field equations with $\Lambda > 0$) is that it introduces a negative pressure>

Dark Energy and the Cosmological Constant

Measurements of Type Ia supernovae (SN Ia) - when interpreted using established theories -suggest that the universe is currently expanding at an accelerating rate, driven by "negative" dark energy. Interpreting the measurement data using the ATH leads to entirely different results. According to this, the universe is still expanding at a decelerating rate today, as predicted by the Einstein-de Sitter universe.

A brief explanation: The measured z-values were evaluated with c = constant. However, according to the ATH ($c \sim t^{-1/3}$), higher recession velocities v result for the same z-value. Relative to c = constant, this would correspond to a larger z-value. Figure 2 shows the measurement data evaluated according to the ATH compared to conventional evaluations. An accelerated expansion of the universe is no longer discernible from this, thereby refuting the main argument for the introduction of dark energy. The SNIa measurement results are therefore not a surprise, but rather to be expected according to ATH.

Dark energy is also not required to explain why the universe is flat ($\Omega = 1$). For if, as justified in[3], one regards vacuum energy as positive energy contained in the energy-momentum tensor of Einstein's field equations, then the sum of all (positive) energies is sufficient for a flat universe ($\Omega = 1$) despite $\Lambda = 0$.

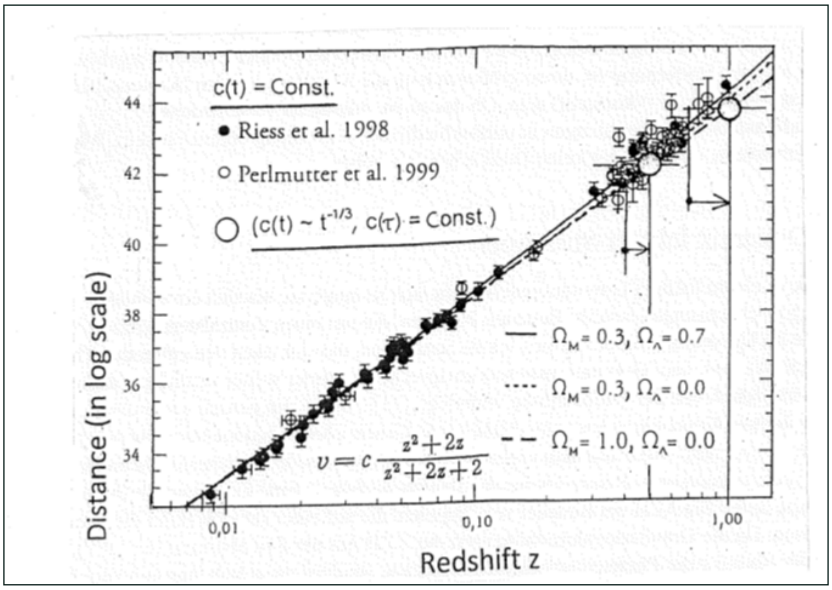

Figure 2: Hubble relation based on measurements of SNIa[7]

The Mystery of the Cosmological Constant Λ

< It remains unsolved to this day and is perhaps the most profound unsolved fundamental problem in modern physics. >[7]

The problem lies in the fact that the value of the vacuum energy density calculated using quantum field theory (QFT) is approximately 122 orders of magnitude (10^{122}) larger than it should be based on observations. According to the ATH, the vacuum energy density[3] εv=0.75 - ε~ t2 (€ = total energy density of the universe). H. Goenner explains how to calculate the vacuum energy density using QFT[8] < In existing quantum field theories, the vacuum energy density generally diverges (ultraviolet divergence), i.e., the integral over the wave numbers k diverges. To avoid infinitely large values, the k-space is truncated at an energy scale Ex = 10^{19} GeV, i.e., at the Planck scale (tp ≈ $10\sim^{-43}$ s). > For the vacuum energy density at the Planck time (tp = 5.4 x 10^{-44} s)—at which point quantum field theory truncates the diverging integral series—the ratio compared to today (t_1 = 4.3 x 10^{17} s) is [3]

$$\varepsilon_{vp}/\varepsilon_{v1} = (4{,}3 \cdot 10^{17}/5{,}4 \cdot 10^{-44})^2 = 0{,}64 \cdot 10^{122} \qquad (11)$$

This result is consistent with the observation.

The AZH thus calls for a completely new interpretation of the concept of vacuum energy:

- The vacuum energy density is positive and time-dependent ($\varepsilon v \sim t^{-2}$), not negative and constant, as current conventional wisdom assumes.
- The cosmological constant does not actually exist ($\Lambda = 0$), and therefore there is also no "dark energy" ($\Omega_\Lambda = 0$).
- Vacuum energy is a component of the total energy of the universe and is contained in the energy-momentum tensor (T_{ik}) of Einstein's field equations. It is independent of the cosmological constant

Does Dark Matter Exist?

Astronomical measurements have shown that the rotational speed of stars around the center of their galaxies is greater than Newton's law of gravity would allow. Based on this and on observations of gravitational lensing, it was concluded that there must be more matter than is visible—that is, an additional form of dark matter. However, some scientists are now considering whether these observations might have other causes, e.g., that the law of gravity must be slightly modified for large distances.[9] < ... so that gravitational forces are, under certain circumstances, slightly stronger than previously thought. This alternative to standard cosmology is conceptually even simpler than the dark matter hypothesis, which speaks in its favor for reasons of scientific theory. Furthermore, the Standard Model of particle physics would not need to be expanded to include dark matter particles and would remain valid. In galaxies, no mass would be “missing” anymore; instead, visible, baryonic matter would cause slightly stronger forces. From the rotational curves of galaxies, a magnitude of 10^{-10} m/s^2 was derived for this threshold. (For comparison: On the Earth’s surface, we experience an -acceleration due to the Earth’s mass that is 100 billion times stronger.) >

Since observing galactic objects always involves looking back in time, we see them as they were as many years ago as the number of light-years they are from us. According to the AZH, gravity was stronger in the past than it is today ($G \sim t^{-2/3}$). Nearby objects should therefore, as measurements confirm, provide little evidence of dark matter. However, the greater the distance, the greater the deviation from Newton’s law of gravitation (G = constant) would have to be. Whether this is the case should be discernible from various gravitational lensing observations at different distances. If this were true, there would likely be no dark matter at all.

The Dynamics of Local Structures

Matter in a local gravitational field continues to attract one another until a stable equilibrium is reached. Example: planets orbiting a central star. Matter in the universe often forms local structures which, according to current theories, should continue to condense over time in accordance with the law of gravity. However, this is contradicted by observation.[11] < It is precisely absurd that.in very small galaxy groups, Hubble’s law is observed just as it is (as for the entire universe)—even with the same value Ho! This highly perplexing anomaly defies every accepted description of structure formation. > The ATH provides an explanation for this anomaly using the example of planets orbiting the Sun in a stable orbit. Since the gravitational constant decreases over time according to the ATH ($G \sim t^{-2/3}$), the radius r of the planetary orbits does not remain constant but must slowly increase to maintain the equilibrium between centrifugal force and gravitational force. Figure 3 illustrates the law governing this orbital expansion. The result:

$$r \sim t^{2/3} \tag{12}$$

The AZH thus predicts that Hubble's law also applies to small galaxy groups and even to planetary orbits and the Moon's orbit. According to the AZH, the Moon should be moving away from Earth at a rate of 2.7 cm/year. Measurements, however, show a rate of 3.8 cm/year. The difference is likely due to tidal braking forces.

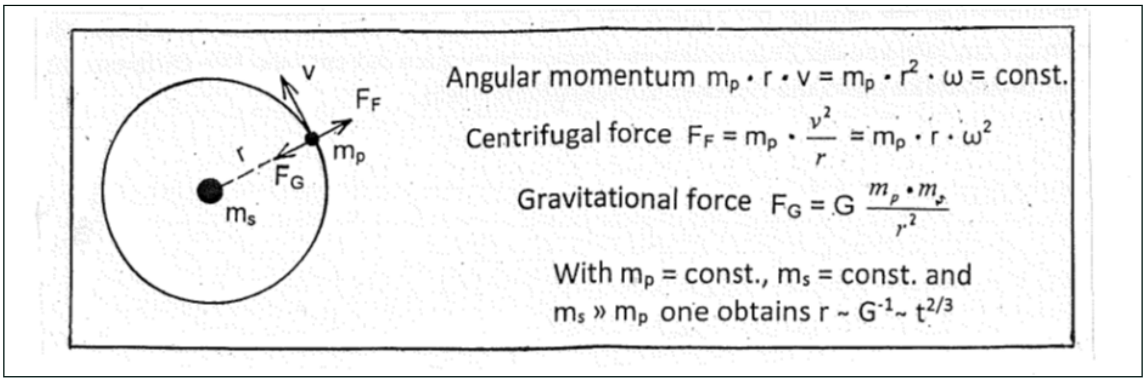

Figure 3: Expanding Local Structures

Unification of the Strong Nuclear Force with the Gravitational Force

Paul Dirac noticed that there are two extremely large, virtually identical numbers, one of which originates from the subatomic world and expresses the ratio of the electromagnetic force (F_e) to the gravitational force (F_G) between nucleons and electrons ($N_1 = e^2/G \cdot m_n \cdot m_e \approx 10^{39}$) and the other measures the scale of the universe ($N_2 = R/r_e \approx 10^{41}$)

Dirac did not believe that the equality ($N_1 \approx N_2$) was merely a coincidence of the moment. To ensure that N_1

$\approx N_2$ holds true at all times, he proposed that the gravitational constant should decrease in proportion to the increase in the size of the universe ($G \cdot R$ = constant), which, incidentally, also applies to the ATH. The ATH offers an alternative to the Dirac hypothesis by linking the gravitational force (F_G) with the strong nuclear force (F_s). This is obvious simply because there is a special relationship between the two forces.

B. Geene points out,[10] < that although the gravitational force and the strong force possess very different properties, they have a similar function: Both are necessary for the universe to exhibit certain symmetries. The same applies to the weak and electromagnetic forces: their existence is also tied to certain gauge symmetries. >

Since the strong nuclear force Fs is 10^{41} times greater than the gravitational force Fa, this results in a nearly exact agreement between N_1 and N_2.

$$N = N_1 = N_2 = F_s/F_G = R/r_e = (t/t_p)^{2/3} \tag{13}$$

Since $G \sim F_G \sim t^{-2/3}$, it follows that the gravitational force F at the Planck time ($t_p = 5.4 \times 10^{-44}$ seconds) was 10^{41} times greater than today and thus equal in magnitude to the strong nuclear force F_s (see Figure 4). This corresponds exactly to what supersymmetry (SUSY) requires, namely that at Planck time, all fundamental forces were unified into a single force.

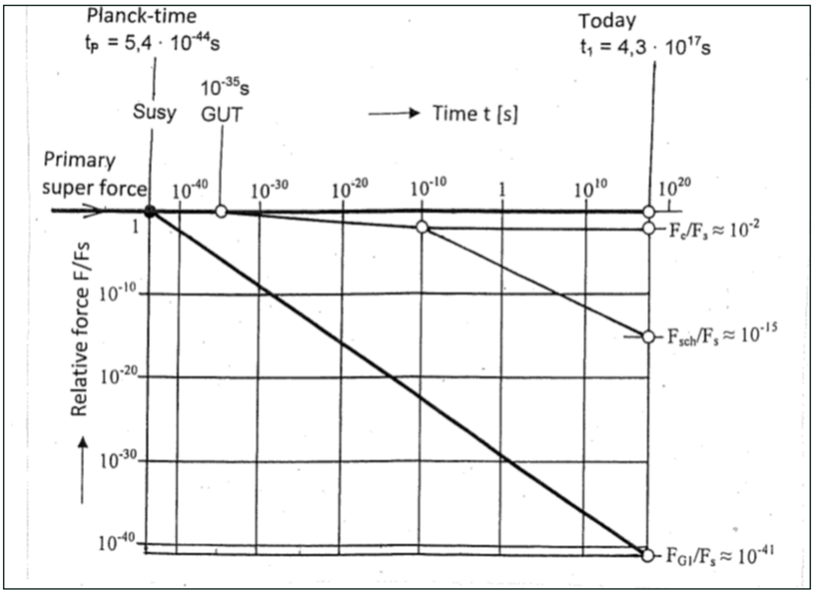

Figure 4: The fundamental forces of nature (F_s = strong nuclear force, F_{sch} = weak nuclear force, F_e = electromagnetic force, F_G = gravitational force)

Summary of Results

- Asymmetric Time transforms the Einstein-de Sitter universe into a new standard model of cosmology.
- ATH elegantly resolves several long-standing problems in Big Bang theory the horizon problem, the flatness problem, galaxy formation, and the age of the universe. This renders inflation theory obsolete.
- It explains why, despite the vanishing cosmological constant ($\Lambda = 0$), the vacuum contains positive energy and why the vacuum energy density εv is smaller by a factor of $\approx 10^{-122}$ than the value resulting from quantum field theory. A result that is compatible with observations. $\Lambda = 0$ means: There is no dark energy.
- The measurement data obtained from observations of Type Ia supernovae, which currently suggest an accelerating expansion of the universe, result - when interpreted from the perspective of the ATH - in a decelerating expansion, as required by the Einstein-de Sitter universe.
- Dark matter, too, might not exist, because the ATH requires that the "gravitational constant" be time-dependent and increase the farther the observed objects are from us in space and thus also in time.

- The time-dependent gravitational constant ($G \sim t^{-2/3}$) leads to a slow expansion of the Earth and thus, along with plate tectonics, contributes to the geological restructuring of the continental crust.
- The ATH answers the question: Why were there supermassive black holes and fully developed galaxies already in the early universe?
- Gravitationally bound local systems, e.g., Earth-Moon or Sun-Earth, expand according to the same law as the universe. This explains,
- The ATH requires that the strongest force (strong nuclear force) and the weakest (gravitational force) must have been unified into a single superforce at the Planck time (tp ≈ 10^{-43} seconds after the Big Bang), were of equal magnitude, and had the same range. According to the ATH, the product of the strength and range of the gravitational force is constant, i.e., independent of time, and is identical to the product of the strength and range of the strong nuclear force.
- The ATH explains why cosmic expansion is permanently in the state of a flat (Euclidean), evolutionarily developing universe.
- In asymmetric time, there was no Big Bang. The universe is infinitely old.
- Space (R), time (), and matter (M) evolve according to identical laws.

$$(R \sim \tau \sim M \sim t^{-2/3}).$$

These results show that the ATH theory provides a better explanation of reality than conventional theories. Whether all of its predictions are consistent with observations remains to be verified through appropriate experiments [1-11].

Symbol

c = speed of light in a vacuum

E = total energy of the universe

G = gravitational constant

h = Hubble expansion (=H/c = 1/R)

k = curvature constant

M = total mass of the universe (=E/c²)

R = World radius

t = "Now-time" = Newtonian time

$\varkappa$ = Coupling constant (= $8\pi G/c^2$)

τ = Asymmetric time

ε = Total energy density of the universe

ε_v = Vacuum energy density (= $0.75 \cdot \varepsilon$)

ϱ = Mass density of the universe

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