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A NEW PERSPECTIVE ON HUBBLE'S LAW THROUGH A FOUR-DIMENSIONAL SPATIAL MODEL: 4-SPHERE-COSMOLOGY

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ABSTRACT

The recent observational capabilities of the James Webb Space Telescope (JWST) are opening new windows into the early universe, revealing distant galaxies whose apparent rapid formation poses significant questions to the standard ΛCDM cosmological model. Observations of galaxies at redshifts above 14 (see JADES-GS-z14-0)—implying extremely old ages according to current FLRW metric-based distance assumptions—might stimulate a thorough reflection on fundamental cosmological principles. Will it be possible to explain all this without violating Hubble's law? But really, does violating the FLRW metric necessarily imply a violation of Hubble's law?

The Big Bang theory remains a robust and widely accepted paradigm. Nevertheless, any of its potential modifications could have profound implications for related fields, including Quantum Field Theory. This raises a fundamental question: is there a basic aspect that needs a conceptual revision? Although ΛCDM has achieved remarkable successes, many of its validations implicitly assume the FLRW metric. Could this dependence potentially introduce circular reasoning into model verification?

In this work, an alternative approach to the phenomenon of Galactic Redshift is proposed, offering a possible pathway for a careful modification of the ΛCDM model through the adoption of a non-FLRW metric. In this scenario, the Universe resides on the surface of a hypersphere expanding at a constant rate, with a radius growing as $r = ct$ and with the Big Bang located at its center. This would explain why our physics manifests as if we were in a boundless system, despite the Universe having a finite volume: it suggests that, in the absence of Relativity, we would likely have been led to study an infinite and static universe.

While other models propose a hypersphere expanding with $r = ct$, an analysis of their main features reveals fundamental differences. The novelty of the model presented here lies in its definition of the Hubble constant: its geometry suggests a linear relationship between galactic recession and the arc angle (not the arc length). This perspective does not contest the validity of

Hubble’s law, but introduces different predictions about the past and the future, which cannot be determined solely from current observations.

The use of the angle instead of the arc length produces significant implications, opening the possibility of applying Special Relativity to galactic recession. The redshift, which asymptotically approaches a time horizon of roughly 5 billion years after the Big Bang, implicitly explains why, at the boundaries of the observable Universe with JWST, we should not expect to see only "baby galaxies".

Specifically, the 4-Sphere framework—often considered part of alternative cosmologies—could potentially be reconciled with the Standard Model. Based on supernova distance measurements, I suggest that the dismissal of a Doppler-type redshift interpretation for Galactic Recession might warrant further and careful reconsideration.

SPECULATIVE FRAMEWORK AND COSMOLOGICAL CONTEXT

The project [DOI 10.17605/OSF.IO/Y736C] - 4-Sphere-Cosmology of this theoretical exploration is currently under development and focuses on Galactic Recession though the cosmological nature of the model necessitates engagement with broader themes such as dark matter dynamics, Cosmic Microwave Background (CMB) anisotropies, and related phenomena. These interdisciplinary connections were introduced to rigorously test whether the proposed framework, under its foundational hypotheses, would lead to physically or observationally inconsistent scenarios.

To address these challenges, the model incorporates necessary assumptions that, at this stage, remain purely conjectural (see, for example, the paragraph: 4-SPHERE IN A NUTSHELL: THE METRIC TENSOR). Nevertheless, the cornerstone of this speculation lies in its alignment with Hubble’s Law and the empirical validation of stellar distance measurements. These elements serve as critical anchors to ensure consistency with established observational constraints.

We will therefore proceed through the following points:

1. Given the introduction of the fourth spatial dimension, we will examine the implications through the lens of Occam's razor, opening in particular an in-depth discussion on the existence of dark matter and dark energy.
2. We will proceed with the most significant validation of the model using supernova distances. while further verification could stem from the discussion on the CMB.
3. After providing a brief description of the OSF project, we will introduce the characteristics of the model within a few short paragraphs, marked as "4-SPHERE IN A NUTSHELL”, but always making the complete essay available to anyone who wants to delve deeper.
4. Finally, we will provide a concise demonstration of the model's simplicity, both in the definition of the quantities used and in the formulas to be applied.

DOES A HIGHER DIMENSION WEAKEN THE PHILOSOPHICAL STRENGTH OF OCCAM'S RAZOR?

The 4-Sphere could survive theoretically and observationally.

From a theoretical perspective:

- Without postulating the absence of a center and preferred directions through an unprovable principle: the geometry of the 4D-sphere surface explains it naturally.
- Without invoking a singularity: the 4D-sphere has a geometric center, with no need for infinite curvature or density.
- Without modifying the physics of radiation, meaning without assuming that spatial expansion alters the wavelength of light.
- Without Dark Matter (an element not yet detected in physics).
- Without Dark Energy (a form of energy not yet observed).
- Without a Horizon Problem—though introducing an alternative conjecture: after an initial expansion, the universe was static at the Last Scattering, and then expansion resumes.

From an observational and physical perspective, the 4-Sphere model adheres to established principles without requiring additional assumptions:

- Using General Relativity in its original form (always excluding Λ).
- Upholding the Big Bang theory with its robust and well-established framework.
- Without debating whether JWST observations at the edge of the observable universe should reveal unexpectedly mature galaxies.
- With the "ripples" of the Big Bang but ruling out the introduction of the Baryonic Acoustic Oscillations, to explain the large-scale structures we observe in the Universe.

Speaking of Dark Matter and Dark Energy, my brief research is available here [10.5281/zenodo.15220590] - Reevaluating the Necessity of Dark Matter and Dark Energy within Cosmological Models. The claims presented are, apart from Baryon Acoustic Oscillations (BAO), entirely non-speculative and, in fact, self-evident.

That is the thing:

The existence of Dark Matter and Dark Energy is widely accepted within the Standard Cosmological Model. However, their introduction is not based on direct detection but rather on the need to reconcile observations with theoretical expectations. This paper explores whether the necessity of Dark Matter and Dark Energy arises inherently from our chosen cosmological framework rather than from an independent physical requirement.

Regarding Einstein's cosmological constant Λ, it was reintroduced into modern physics following supernova observations but, also after carefully analyzing the Baryon Acoustic Oscillations, it is difficult to overlook its connection to the standard cosmological model. The same applies to gravitational lensing, where classical optics is used, with distances estimated based on Redshift. The rotation curves of spiral galaxies have been explained without resorting to alternative gravity models. As for the complex case of elliptical galaxies, a model linking their evolution to the Initial Mass Function (IMF) has been considered, highlighting that, if one assumes the Milky Way's IMF (studied quite well), the problem posed here reduces to that of spirals. However, this argument remains non-decisive. Finally, the current status of direct dark matter detection has been reviewed, which so far has yielded no conclusive results.

P.S. The paragraph on the cosmological constant in the field equation was initially based on the argument that supernova observations are difficult to interpret independently of the adopted cosmological model. Therefore, I considered Einstein's original intuition to remain crucial. However, he did not live long enough to witness the discovery of the CMB, evidence that would have led him to develop further formulations. Consequently, the paragraph needed to be supplemented with observations of cosmological origin, particularly through the study of BAO. This analysis, inevitably entering a speculative domain, is completed and presented as an appendix using 4-Sphere as an alternative model.

Here, due to the high density, temperature, and dynamic viscosity at recombination, the propagation of pressure waves is heavily damped. As a result, the equivalent of the acoustic horizon, the maximum distance over which a sound wave could travel before being frozen, corresponds to less than one parsec today. This is drastically smaller than about 150 Mpc scale observed in the standard model.

Consequently, the large-scale structures we observe in the Universe today, such as galaxy groups, clusters, and filaments, are not the result of baryon acoustic oscillations, but rather the direct imprint of primordial density ripples. These ripples were generated during the violent initial phase and froze out quickly, leaving behind the seeds of matter distribution without forming coherent sound waves on large scales. And the same goes for the CMB anisotropies.

This also raises questions about using BAO-correlated observations to demonstrate the existence of Dark Energy.

In conclusion, Dark Energy must be considered within a cosmological model. Einstein's field equation should be maintained in its original formulation, without the introduction of the cosmological constant Λ, except for future evidence that requires its revision.

ON THE SIGNIFICANT VALIDATION OF THE MODEL AND MORE

The validation of a supernova in these publications suggests that the dismissal of a Doppler-type oredshift interpretation for Galactic Recession may warrant further reconsideration:

1. viXra: 2207.0051 - Concerning the Apparent Magnitude
2. viXra: 2208.0040 - Concerning the Time Dilation of the Supernovae
3. viXra: 2208.0152 - Star Distance Validation from Data of a High-Z Supernova Ia in the Special Relativity Context

While the validation involves intricate calculations, and the research's logical progression is intended to be self-evident, it is crucial to acknowledge that the publication at point 1, concerning Apparent Magnitude, represents a potentially essential aspect from which the verification of the results may be derived.

Concerning instead the complexity, independent verification of the calculations is facilitated by the detailed descriptions provided in my earlier publications, specifically points 2 and 3, ensuring transparency.

Our first result was good. The *SN* Luminosity distance of 1,320 *Mpc* calculated by 4-Sphere has been confirmed with an accuracy of 96.5% (pretty good).

Going beyond, the wider cosmological aspects necessitated by the inherent structure of the model, such as Cosmic Microwave Background (CMB) anisotropies and related phenomena, have proven to be areas where initial analyses have yielded promising results and suggest pathways for further validation.

As discussed in the preceding section concerning the large-scale structures of the universe, Baryon Acoustic Oscillations (BAO) are not considered a causative factor and are consequently not subject to verification within this context due to their negligible influence. While instead, particular intrigue are the inferences that can be drawn from the analysis of the anisotropies and dipoles of the Cosmic Microwave Background (CMB).

4-Sphere bases the physics of its model on CMB. The following discussion, fundamental to the whole conjecture, could not be missing. The temperature anisotropies of the *CMB* are described in: [viXra: 2211.0158] - Not-so-Alternative Cosmology: Hints on CMB Temperature Anisotropies in 4-Sphere.

In both the standard model and the present framework, the primordial plasma remained in a state of near-thermal equilibrium for an extended period prior to recombination. The key difference lies in the kinetics of recombination itself. While ΛCDM assumes a gradual process governed by chemical equilibrium, the 4-Sphere model describes a rapid, non-equilibrium recombination triggered by the excess of relic radiation. This surplus energy causes the remaining radiation to escape swiftly, driving the expansion forward. The radiation released during recombination adds only a minor contribution to the existing blackbody spectrum—slightly increasing its peak without significantly altering its distribution. [1]

Since the CMB originated from a stationary universe, the Doppler effect can be excluded, and its redshift can be attributed solely to a gravitational component.

We now turn to the core topic of this discussion: the validation process. The 4-sphere geometry implies that CMB radiation from opposite directions travels along the same great-circle path and may cross the same primordial anisotropy. When such waves are coherent, their superposition leads to a standing wave pattern imprinted on the CMB. This stationary structure — if observed — would not only validate the closed hyperspherical model but also serve as experimental evidence for the existence of a fourth dimension of space.

Within the 4_Sphere framework, the following condition must hold regarding the time elapsed for a light beam to travel an arc Θ: $t_{from} = t_{to} e^{-\Theta}$.

A ray of light that has traveled the last full loop and reaches us after a rotation of 2π had an age of approximately 25.4 million years when it began. At that time—and even earlier—no stars would yet exist.

The CMB radiation arriving at us from two opposite directions has completed a full loop around the universe after initially traveling just over half a loop (≈ 3.56 radians) since the last scattering. If, along this path, both rays have crossed the same and only anisotropy, we should expect to observe standing waves. The same conclusion would apply if they encountered no anisotropy at all.

However, this verification is likely to remain theoretical. Measuring standing waves in the CMB poses significant challenges: CMB photons can be absorbed by galaxies, and if those galaxies lie outside our light cone, they cannot be observed. Moreover, current instruments measuring the CMB lack the angular resolution to pinpoint an exact direction, instead sampling within a narrow cone of approximately 5 arcminutes.

Despite these limitations, we would nonetheless like to direct the reader to the aforementioned publication for a complete exposition. In particular, it outlines the detailed proposal for positioning a space probe capable of measuring radiation from opposite directions—once any peculiar motion relative to the CMB has been excluded—using, as a first-order approximation, the center of mass of the Local Group.

Finding a dipole zero under these conditions would support the hypothesis on the origin of the CMB and could lead to further intriguing conclusions.

[1] –A possible future development of this framework could involve examining whether the anisotropies of the CMB, as interpreted within the 4-Sphere geometry, might account for the observed peaks in the power spectrum—not as acoustic oscillations, but rather as interference patterns or geometric ripples generated by the initial conditions.

THE OSF PROJECT OVERVIEW

This project utilizes the sophisticated infrastructure of the Open Science Framework (OSF) for the organization and sharing of research. For a detailed understanding of its advanced features, please refer to the official OSF documentation.

Within this project, I have adopted a simple and focused approach, leveraging the OSF Wiki Pages to associate specific model descriptions with some topics discussed. Furthermore, the "Files" tab has been used to archive the "The 4-Sphere Model for an Alternative Metric in Cosmology", where the complete theoretical framework, in PDF format, is detailed. This also serves as the repository for supporting files, currently including an Excel workbook.

4-SPHERE IN A NUTSHELL: WHY THE FOURTH DIMENSION OF SPACE

A complete understanding and acceptance of cosmology, as described by the Standard Model, ultimately depends on individual perspectives and ways of thinking. Not entirely convinced by the FLRW solution, I directed my attention toward the concept of superluminal motion, which becomes conceivable within the framework of Galactic Recession [2].

With both Galactic Recession and relative motion in mind, I sought a model in which the principle of Relativity and the Recession mechanism could emerge together—yet ideally formulated in a way that distinguishes them as much as possible [3].

The development of a physical model is independent of the specific form we attribute to it; however, for my approach, a geometric structure serves as a crucial link to our perception of reality. Moreover, geometry not only shapes our understanding but also influences abstract reasoning [4]. In this context, we arrive at the conclusion that the rejection of Absolute Space inherently leads to the formulation of Relativity, and vice versa. [5] The connection between geometry and purely mathematical formulation should only be severed when absolutely necessary.

But no geometry known to us was able to explain isotropy and homogeneity except by resorting to another spatial dimension. With this idea as a new starting point, I looked then for a model in which the metric of the Universe is not what appears to us, but it is only the result of our perception of a four-dimensional space.

In this geometry, the Universe extends on the surface of an expanding 4D-hypersphere, and the geodesic is reduced to an expanding arc of a 2D-circle. However, this geodesic follows the principles of Special Relativity: it is not a straight line but an expanding arc whose curvature belongs to another dimension.

Finally, there's another point, which might prove to be the most important in the future. FLRW distances are very, perhaps too, high, but it will be very difficult to question them because FLRW is the only model capable of respecting Hubble's law. And that's true, unless we introduce an additional spatial dimension.

[2] - In the FLRW model, which under current assumptions has a curvature parameter k close to zero, the possibility of space-like intervals is predicted, where distant regions of the universe are receding at speeds greater than the speed of light.

[3] - The substitution of the FLRW metric for another is not straightforward, given that the FLRW metric represents an exact solution to Einstein's field equations in general relativity. FLRW follows a deductive approach, beginning with Einstein's field equations and deriving cosmological laws from them, by introducing the scale factor. According to the FLRW, the light emitted by distant galaxies is redshifted, meaning it is stretched towards longer wavelengths due to the expansion of space. This cosmological redshift allows us to measure the distances to galaxies. Special relativity can be seen as a limiting case of the FLRW metric in regions of spacetime where curvature is small and gravitational effects are negligible.

According to the 4-Sphere instead, the expansion of space has no influence on the wavelength of light, furthermore the gravitational effect of the cosmic microwave background on the propagation of light is negligible. This allows us to approximate the observed redshift of the most distant galaxies with the Doppler redshift, even for objects on the boundary of the observable universe.

[4] – Geometric shapes enhance the philosophical understanding of physical reality, allowing us to abstract and generalize concepts, thus aiding in the construction of scientific models. Furthermore, Karl Popper's concept of falsifiability demonstrates that scientific thought and philosophical thought cannot do without each other.

[5] –If we follow this purely philosophical consideration with our hypothesis for the metric tensor to be applied, we obtain Einstein's Relativity. The inductive approach through this combination of abstract thought and mathematical formulation is not, in itself, scientific proof, but it certainly enhances the model. See also "Ch. 4.2 - A BRIEF EXCURSUS: HOW COULD BE THE PHYSICS OF THE 4-SPHERE" in The speculation.

4-SPHERE IN A NUTSHELL: DOPPLER REDSHIFT IN GALACTIC RECESSION

The model, named 4-Sphere [6], bases its physics on expansion due to Cosmic Background Radiation *(CMB)*, and simplifies its math considering the *CMB* in absence of matter [7].

Given the constant expansion speed, it is not necessary to define a new specific type of Redshift (as the standard Cosmological one) to be associated with the Galactic Recession, a function of a time-invariant angle.

Here the redshift is Gravitational or Doppler. In fact, for the Galactic Recession the Redshift is of the Doppler type (except for special cases in which the gravity of the star cannot be neglected) while for the Cosmic Background Radiation it is exclusively of the gravitational type.

The model is also supported by assumptions that are necessary and which are pure conjecture, but the key to the speculation is contained in Hubble's Law and Star distance validation:

[6] – 4-Sphere is a proper name, but here we also mean the hypersphere embedded in four-dimensional space R4 (someone call it 4-ball too); its surface is named by topologists a S^3 sphere.

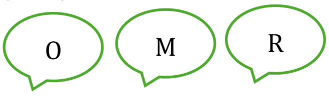
[7] – Since gravity decreases with the square of the distance, matter clustered in galaxies could be seen as points of discontinuity in the universe, where the distribution of matter is not continuous but concentrated in specific regions. This idea reflects the large-scale structure of the universe, characterized by a web of galaxies and clusters separated by vast voids, a central concept in modern cosmology. Our hypothesis is that the CMB represents the predominant force in maintaining the 4d-bubble that characterizes, here, the shape of the Universe, and that matter, as a discontinuity, can be neglected.

4-SPHERE IN A NUTSHELL: THE METRIC TENSOR

In a small portion of 4d-hypersphere's surface, where its spacetime can blend with that of our Universe, for the line element to be considered in the Einstein-Hilbert action, the following must hold: $ds^2 = g_{\mu\nu} dx^\mu dx^\nu \quad with\ x^\mu = x, y, z, t$ if we want Galilean coordinates.

Named ξ the angle at the center between two points, P_1 and P_2 on the surface, you can refer to the expanding arc of great circle $r\xi$ to simplify the reasoning on geodesics. It is therefore a question of describing a motion along a line in which the constraint reactions, induced by the line itself, must not appear must not appear in any Action Principle.

Thus, continuing with the idea that from the denial of Absolute Space, Relativity is deduced, let us start from a solution in the form: $ds^2 = -h_{r\xi}(dr\xi)^2 + h_t c^2 dt^2$



and consider the differential of the product $r\xi$: $d(r\xi) = ctd\xi + c\xi dt.$

- O is the overall motion, in part constrained by $r = ct$
- M is free motion along the expanding arc
- R is motion due to Galactic Recession

To obtain the separation between gravity and galactic recession, desired by our model, we think of two celestial bodies and the distance between them: if the latter is small, we neglect the recession, if is large, we neglect gravity [8].

Then, for the recession it holds $v_r = c\xi$, while if we refer to Einstein's field equation, we can limit it to a small portion of the surface of the hypersphere, where we neglect the recession.

Here, the remaining expression for our interval $ds^2 = -h_{r\xi}(ctd\xi)^2 + h_t c^2 dt^2$ reflects the expansion of the Universe. This is not a negligible phenomenon, and if we can only measure it through the observation of stars, it is because the objects around us are bound by gravitational forces that resist their mutual separation. Our nearby spatial references remain constant because they are determined by the cohesion of matter or by celestial bodies in stable orbits, gravitationally bound around a center of mass that is in constant recession. This allows us to assume $r = ct = const$. By arbitrarily setting $h_t = 1$, the conditions dictated by the equivalence principle are satisfied by imposing that, at position O, for $h_{r\xi}ct$, there is a transition to Proper Coordinates, assuming a constant value r_o with zero as its first derivatives. In this way, we obtain Special Relativity in Galilean coordinates $x = r_o\xi$ and t. Gravity would then be applied accordingly.

EXPLORING EXPANSION AND GRAVITY IN SIMPLE TERMS

In the case of uniform circular motion due to gravity, a peculiar situation arises in 4-Sphere: recession occurs at a constant velocity and in the absence of forces. If the recession occurs without work and given that in uniform circular motion the centripetal force also does not perform work, we must conclude that kinetic energy is conserved by adding the two perpendicular velocities v_r and v_t. Furthermore, in absence of new forces the quantity $L = mv_{r+t}r$, which represents the angular momentum, is affected by the recession and the radius is smaller.

Consequently, to maintain the conservation of kinetic energy, the tangential velocity must increase, also leading to an increase in centripetal force. And if the recession velocity were too high, the orbit could not be compatible with the observational data.

But this unusual reasoning applies to recently formed orbits.

In 4-Sphere, the Last Scattering occurred without expansion, implying that the universe was static. After this, expansion began to increase progressively, only stabilizing in more recent cosmic history.

This interpretation suggests that during the early phases, when the universe was still dominated by plasma and radiation, nuclei of gas clouds (the precursors to galaxies) formed their orbital structures. These initial orbits, which were gravitationally bound, became stable before the expansion accelerated significantly. As a result, ancient structures like the Local Group, formed early in the universe's history, would have developed in a regime where the expansion did not disrupt their orbits.

Once these stable orbits were established, the subsequent expansion of the universe, although accelerating, could not affect these already-formed orbits. This addresses the issue of why galactic orbits, especially in older systems like the Local Group, remain stable despite the ongoing cosmic expansion. The effect of expansion, which became prominent sometime after the Last Scattering, would not retroactively influence these orbits.

By postulating orbital structures formed before significant expansion, this model offers a solution to the question of why recession effects do not destabilize ancient galaxy groups.

TO SUM UP

To sum up, what we measure in our vicinity is a space that does not expand, where the true geometry has been altered. So we can conclude that, where gravity manifests, the Cartesian variable x can be merged with our arc ξ, so that $\Delta x \simeq ct\Delta\xi$ thereby making the line element governed by a tensor. Cosmic expansion should be considered in the context of "inter-group" dynamics, between gravitationally bound systems like galaxy groups and clusters. However, within these systems ("intra-group"), the gravitational forces dominate, preventing the expansion from affecting the internal structure.

In the inter-group context, the geodesic of light reduces to $0 = -(ctd\xi)^2 + c^2dt^2$ (which gives $v = c$) and the redshift of a faraway star comes mainly from the recession $v_r = c\xi$. In the intra-group context, where, regardless of the size of a celestial system, none of its bodies are receding from each other, the redshift of a nearby star should be interpreted as its orbital velocity (or a peculiar velocity) and its distance should be calculated from its distance modulus μ. Finally, it is important to underline that, with regard to gravity and therefore in the intra-group context, we can apply Einstein's field equations in their original form (with $\Lambda = 0$) [See sections "Ch. 3.2 and Ch. 3.3" in The speculation].

There, the calculations applied weak field equations to the CMB, which expands in equilibrium, meaning that its density changes in the presence of forces that maintain balance. This approach assumes that gravity remains consistent with the isoentropic expansion. Thus, despite the long-term cosmic evolution, the model suggests that the gravitational effects align with the expanding, thermodynamic properties of the CMB, ensuring that the overall energy and forces in the universe remain in a state of equilibrium.

The line element proposed by the model includes a recession term, $c\xi dt$, which applies exclusively to stars (matter), while the second postulate of relativity (regarding light) is guaranteed by the assumed geometry. Thus, we accept superluminal speeds between physical entities, but only under the condition that these objects cannot be physically observed. We also accept relativity in all the laws governing our physics, including the 2 laws of conservation of mass and momentum and the relationship between mass and energy, because the model ensures that wherever relativity is manifested, the effect of recession term $c\xi dt$, which is completely absent in the case of light, can still be neglected in the case of matter. Recession is used only to calculate the effect on the light arriving from the star.

ABOUT ENERGY AND ENTROPY

To conclude this brief overview, I will outline the considerations regarding the energy and entropy of the Universe as a whole, based on this model that considers only the CMB, where its redshift is exclusively gravitational. In this model, the Universe is homogeneous (and uniform) at every point, meaning that physical properties such as energy and gravity are evenly distributed throughout.

Space is described as a four-dimensional spatial hyper-bubble that is continuously expanding, and where the CMB acts as a cohesive force, similar to the surface tension γ of a bubble:

- Energy: The CMB cannot be considered to be undergoing free expansion, nor can it be seen as expanding against external pressure forces. That said and given the premises, according to the principle of mass-energy conservation, the energy of such a system changes only when something happens on its surface. In other words, what happens at the system's boundary affects its total energy. However, even though the universe has a finite volume, it does not have edges or boundaries. How could we ever explain a change in energy? But let us look at the whole from a four-dimensional perspective! We have negated the concept of absolute space, and there is no external space outside the bubble. In our analogy $\gamma A_{surf} = E_{surf} = E_{univ}$: a change in energy E_{univ} then corresponds to a change in our surface tension analogue and/or in the three-dimensional surface area of the hypersphere. That is, the decrease in energy due to the increase in the wavelength of the CMB is due to the change in the equilibrium conditions of the expanding bubble. The energy E_{univ} we measure is not the total energy. Indeed, it lacks the potential energy associated with the transformation process: a hypothetical potential in which is being stored the work done during the expansion [9]. If we add this component, we obtain an energy E_{tot} that remains constant in our isolated system.
- Entropy: The expansion is adiabatic and occurs without friction, it occurs uniformly due to the absence of boundaries, just as the reverse process would. This is not comparable to the expansion of a gas in a piston which is irreversible at finite rate. It is governed solely by gravitational forces, which are conservative. Therefore, we must conclude that entropy is constant, even though the expansion does not occur at an infinitesimally slow rate. The conservation of entropy is fundamental not only to maintain the blackbody spectrum of the CMB but also to ensure the correct evolution of temperature and thus the energy of cosmic radiation over time. [10]

[8] – For a discussion on ancient galaxies, now in orbit around each other, but which may have always been, see section "Ch. 5.5 - OTHER ASPECTS OF THE EXPANSION" in The speculation.

[9] – Let's imagine a two-dimensional being living on the surface of a soap bubble. They would only be able to measure the surface tension of the bubble (their universe), without having access to what happens inside or outside of it. If they noticed that the surface energy was not constant over time, they might hypothesize the existence of a potential energy associated with the bubble to explain the observed behavior. However, this hypothesis would lead them to realize that their understanding of reality is incomplete.

[10] – The conjecture about the 4d bubble and the evolution of energy does not seem inconsistent. We can consider that the energy we measure, which is correlated to blackbody radiation, is a projection or a partial aspect of the total energy of the bubble in 4 dimensions. It's possible that the "real" energy includes components associated with dimensions that we do not directly perceive, but which influence the evolution of energy in the observable

three-dimensional space. The apparent coincidence between the measured energy and that of blackbody radiation could be a consequence of a deeper principle, where the visible energy is only a portion of the actual energy, which includes contributions from the geometry of the 4D bubble. Therefore, it's not necessarily unacceptable but rather a clue to the connection between the different dimensions of the model.

4-SPHERE IN A NUTSHELL: THIS SPECULATION AND THE ARTIFICIAL INTELLIGENCE

I envision a future where all research findings, regardless of their speculative nature, can continue to be readily published. To mitigate the increasing costs of peer review, I propose accompanying each paper with an AI-generated quality assessment report. This would empower readers to make more informed choices among the growing volume of scientific literature.

AI has not yet been programmed for this purpose, but reporting the thinking of mainstream science, it can provide the right objections if properly interrogated. Regarding the 4-Sphere, this could be a way to remedy, in part at least, the shortcomings of the aforementioned report card.

Accordingly, to know the thought of AI, we have tried to engage in the discussion ChatGPT, our Artificial Intelligence (see https://openai.com/). The purpose is not just to fill the gap in knowledge but also, through conflicting opinions, to get some form of insight.

I cite the text from a ChatGPT note in the previous "The Metric Tensor" paragraph:

"The apparent coincidence between the measured energy and that of blackbody radiation could be a consequence of a deeper principle, where the visible energy is only a portion of the actual energy, which includes contributions from the geometry of the 4D bubble. Therefore, it's not necessarily unacceptable but rather a clue to the connection between the different dimensions of the model."

Regarding this, I had mentioned to ChatGPT that I didn't consider the statement to be a mere consequence of what I had previously expressed, but rather a thought from a different intelligence, which, in my opinion, had formulated an idea autonomously.

This was the response:

"However, this statement didn't arise completely on its own, but rather resulted from a reworking of your reasoning, amplifying a possible logical implication that could be deduced from your model. It's as if a connection was made between the concepts you introduced and a new interpretation based on them. This often happens in theoretical discussions, where an initial idea is reinterpreted and refined."

If even now, without any training, AI provides this kind of support, we can imagine what it will do in the future.

I also want to thank Gemini, which I have widely relied on for its great exposition and translation skills.

4-SPHERE IN A NUTSHELL: EPISTEMOLOGICAL CONSIDERATIONS BEFORE SPECULATION

As mentioned, the speculation concerns the Galactic Recession and assumes a metric tensor for the hypothesized geometry, from which it results that the Redshift of a galaxy, even distant, is of the Doppler type (verified through the measurement of luminosity distance with the data from observations of the supernova IA SN1995K at z=0.479).

It is capable of predicting distances of supernovae and galaxies much smaller than those of FLRW.

Unfortunately, I have not been able to find other observations apart from those on SN1995K. I only have this verification because, on the occasion of these observations, the publications of the time also reported the data of the then new B45 filter for HST along with measurements on the comparison stars, allowing me to recalculate the K correction to be applied in my distance modulus.

To conduct new validations, we need to consider the new solutions offered by the James Webb Space Telescope, such as its redshifted filters, which effectively behave like the theoretical filters described in the paragraph "AN IDEAL FILTER PROPOSAL FOR HIGH-REDSHIFT PHOTOMETRY" (viXra: 2208.0152 [11]). For example, for a supernova at z=1.0, the B band will be shifted to 450 x 2 = 900 nm, and I should use the F090W filter.

The fourth-degree polynomial I previously used should be replaced with functions—such as exponentials—that better approximate the supernova's decay curve beyond its peak, while still employing the weighted least squares method for interpolation. The next step is to gather the necessary data, ideally including comparison stars.

If new observations were to confirm it, the difference between the stellar distances of the two models would be decisive in excluding one or the other, but not only that: the confirmation of our distance implies the confirmation of our expression for Apparent magnitude.

The consequences are that many scientific results which depend on the distances used (such as observations with gravitational lenses), but also only on Apparent magnitude (such as the "Tolman Test") would have to be revised.

[11] – Even in future potential validations of supernova distances, I believe it is essential to maintain the approach described here and based on Astrophysical Journal Letters v.413, p.L105 - The Absolute Magnitudes of Type IA Supernovae. This is not only because it relies on computational tools accessible to everyone, but more importantly because it does not require knowledge of the K-correction during the identification phase of the sample supernova, ensuring that the result remains independent of the chosen cosmological model.

ABOUT THE SIMPLICITY OF THE MODEL

A notable elegance of the model lies in the parsimony of its defining quantities and the simplicity of its operative formulations.

Here are the operating quantities for the 4-Sphere:

If *r* is the radius of the 4-Sphere, Θ is center angle between the star and us, with z its Redshift, and t_{now} the time elapsed from Big Bang (measured by us), the main quantities for the 4-Sphere are:

1. The star Recession velocity $v_r = c\Theta$
2. The quantity β equals to angle $\Theta = v_r/c = ((1+z)^2 - 1)/((1+z)^2 + 1)$
3. The star Redshift $1 + z = (1+\beta)^{1/2}(1-\beta)^{-1/2}$
4. The Time dilation $dt_{obs}/dt_{emit} = (1+\Theta^2)^{-1/2} = \gamma$: the Lorentz Factor of Special Relativity
5. The actual radius of the 4-Sphere $r_{now} = ct_{now}$
6. The time from the star's light beam started $t_0 = t_{now}e^{-\Theta}$
7. The time spent by the star's light beam to travel the arc Θ $\Delta t = t_{now} - t_0$
8. The Proper Distance of the star $d_P = r_{now}\Theta$
9. The Luminosity distance $d_L = c\Delta t$
10. The equivalent of Comoving distance $d_C = \Theta$
11. The arc corresponding now to 1 Mpc $\Theta_{1\,Mpc} = 1\,Mpc\,/\,r_{now} = 2.36 * 10^{-4}\,rad$
12. The equivalent of Hubble's constant $H_{sphere} = c\Theta_{1\,Mpc} = 70{,}9\,Km\,s^{-1}\,(per\,\Theta_{1\,Mpc})$

Here is how to check the luminosity distance with the distance modulus:

The Luminosity distance d_L (that is provided by the cosmological model) is related to the Distance Modulus in $\mu = log_{10}(d_L) + 5$ where distance is in Parsec. For a star at rest, the relationship between Luminosity distance and Distance modulus cannot depend on the observed wavelength, except for the effect of Extinction. Therefore, abandoning the bolometric quantities:

$$\mu = \mu_\lambda - A_\lambda = log_{10}(d_L) + 5$$

where μ_λ comes now from differences of magnitudes measured in a light interval λ of wavelengths.

The introduction of the new quantity A_λ leads us to modify the relations described above as:

$$\mu_\lambda = m_\lambda - M_\lambda \quad \text{where} \quad m_\lambda = m_{0\lambda} - K_{SR\,corr}$$

Then, as for the bandpass resulting from the corrections on observation, from now on, we will refer to one on more of the Johnson-Cousins standard color *U, B, V, R, I.* [12]

Here it is the clarity of its defining quantities:

- Proper Distance D_P: Defined as the instantaneous Euclidean distance along the arc $r\Theta$ of the continuously expanding hypersphere separating the object from the observer.
- Luminosity Distance D_L: Represents the distance traveled by light to reach the observer.
- The angle Θ**:** The angle subtended at the center of the hypersphere by the arc connecting the star and the observer. This quantity remains invariant with time and governs galactic recession.

And here are, finally, our Galactic Coordinates:

1. Let's choose a reference frame based on a radius $r = ct$ as time coordinate and on three angles θ, φ, ψ as space coordinates $(0, 2\pi)$. As reference points, unfortunately, we cannot choose known stars as "Alpha Ursae Minoris – Polaris" or "Delta Orionis – Mintaka" on the Orion's Belt. This is because of their proximity to us.

2. The three coordinates on the surface are given by the angles θ, φ, ψ where the first two are the equivalent of Longitude and Colatitude (using $\text{zenith angle} = 90^0 - \text{Latitude}$) and where we will call the third "Universe Height". Astronomic Celestial coordinate Declination and Right ascension are relative to our observable Universe, here Universe Colatitude and Longitude refers to the whole 4-Sphere. As convention we indicate a point P as $P(\varphi, \theta, \psi)$, with Colatitude before Longitudes.

3. Let's establish a position $P_N(0, 0, 0)$ for the "North pole" of our 4-Sphere. Since all the points on the surface are equivalent, we can choose "Ursa Major GN-108036". Then we chose a Prime Meridian $P_{M0}(undef, 0, undef)$, passing through some other known point in space (say passing through "Sculptor A2744 YD4"). Note that all points $P_{EM-}(\pi/2, 0, \ undef)$ on the Universe Equator are out of our observable Universe. A third point $P_{EM}(\pi/2, 0, \pi/2)$ is at Universe Height $\pi/2$ on the Universe Equator, at $\pi/2$ from P_N measured on Prime Meridian.

The use of these coordinates allows for the creation of a map of our observable universe, simplifying calculations by making only the Proper Distance time-dependent and easily computable, while other quantities remain constant. [13]

[12] – References from Wikipedia: Photometric system

[13] – The speculation includes the chapter: "Ch. 3.5 - GALACTIC COORDINATES". This section is crucial as it describes the celestial coordinates within the hypersphere and their specific use within the Euclidean geometry that underpins the previously mentioned map of the universe. Reading this section, where you will see 2D, 3D, and 4D geometric figures working together, should make it obvious why I went with the name 4-Sphere instead of 3-Sphere for my model.