# Shape and Size of the Universe: challenging the Standard Model of Cosmology

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**Abstract** The standard model of cosmology (SMC) is based on the Friedmann equations, which are derived from Einstein's field equations of gravity for the Friedmann-Lemaître-Robertson-Walker (FLRW) metric. The Minkowski spacetime (MST) metric, which can explain all aspects of special relativity (including time dilation, length contraction, and relative simultaneity), describes spacetime far from massive objects. This article contends that the currently accepted mathematical interpretation of the MST metric (as well as the FLRW metric) is incorrect, which has misled cosmologists from reaching a definite conclusion about the true shape and size of the universe. The temporal parts of both metrics are identical, and either metric can be used to determine the shape and size of the universe if the mathematical interpretation is corrected. The universe is like the 3D hypersurface of a 4D hypersphere; or in other words, the shape is like a (hyper) balloon. The shape is not plane (i.e. not 3D flat), and it is not infinite; it is a finite 3D hypersurface. Astronomers are confident that they have measured the universe to be 3D flat using two different methods. However, neither method can measure the extrinsic curvature of a 3D hypersurface. Also, other exotic shapes for the universe, like torus (doughnut) or dodecahedron, need not be considered. The universe is expanding like a balloon. Taking the radial expansion velocity of the universe as *c* (as dictated by spacetime equations) and the age of the universe as 13.8 billion years, the value of the Hubble constant obtained using this model (71.002 km/s/Mpc) agrees well with the accepted values (69.8 and 74 km/s/Mpc calculated by two different methods). Presently accepted SMC cannot explain why it has this particular value of Hubble constant. SMC cannot provide a satisfactory answer to the question "If the universe is expanding, what is it expanding into?" Additionally, SMC faces embarrassing situation trying to answer "Where is the centre of the universe?" The model presented in this paper provides clear answers to both questions. Since the MST metric and Hubble's law both say the same thing in this presented model, it demonstrates that this model is correct.

***Keywords:*** *shape of universe; size of universe; structure of universe; geometry of universe*

## 1. Introduction

A recent study by Melia [1] called into question the standard model of cosmology (SMC) in eight different aspects and highlighted its serious shortcomings. The author claims that a complete revision of the standard model of cosmology is needed. He also claims that each of these points is serious on its own. When taken together, even the most ardent supporter of the standard model of cosmology must agree that it is time for a complete paradigm shift, as many scientists have argued. Kroupa [2] claims that the properties of dwarf galaxies exhibit several irregularities, in particular a strongly anisotropic spatial distribution and strong correlations between acceleration and mass discrepancies. Any model of the universe that invokes dark matter cannot explain these types of irregularities. As the dark matter premise is essential to the SMC, this issue poses a major problem for the SMC. Kroupa [3] also states that the major issues with inflationary Big Bang (BB) cosmologies remain unsolved, which again is problematic for the SMC (which cannot do without cosmic inflation).

The SMC is like a patchwork dress stitched together from diverse ideas and tailored to fit an astonishing number of different observations. Consequently, it is more of a placeholder than a coherent model. Some experts have even asked, “Do we have a standard model of cosmology?” [4]. Several authors have noted problems that this model faces [5]. Martín López-Corredoira had made scathing attacks on the SMC. His unrestrained attacks on the SMC is a delight to read, and has been included in **Appendix A**.

Melia is not the first scholar to challenge the standard model of cosmology [1]. In fact, Melia et al. [6–8] developed a new model of the universe, called the $R_h$ = ct universe. As already shown by Melia [9], the radius of the Hubble sphere coincides with the gravitational horizon radius ($R_h$). Melia's $R_h$ = ct is a constant expansion rate model of the universe (as opposed to the accelerating model of the universe in the SMC, which is also known as the Lambda-Cold Dark Matter (ΛCDM) model or the Concordance Model).

The model presented in this article is a special case of the $R_h$ = ct universe mentioned above. However, it is much more refined and restricted. More importantly, it is based on the correct interpretation of the crucial equations of spacetime (rather than based on assumptions). The model proposed in this paper shows that the true radius of the universe ($R_{Univ.}$) always remains equal to the Hubble radius, because the speed of light (which determines the value of the Hubble radius) always remains equal to the radial expansion velocity of the hyper-balloon universe. This article shows that the speed of light (as well as the speed of gravitational waves) is fixed at the particular value c (which is actually the radial expansion rate of the universe) due to the peculiarity of the Minkowski SpaceTime structure.

The model presented in this manuscript can inherit the successes of the $R_h$ = ct universe. Therefore, it may be advisable to mention them. Wei et al. showed that in a pairwise comparison, the probability of the $R_h$ = ct model being correct is 90%, compared to only 10% for a minimalist form of the ΛCDM model, in which dark energy is simply a cosmological constant [10]. Compared to the $R_h$ = ct model, versions of the standard model with more elaborate parameterizations of the dark energy are even less likely. Wei et al. claimed that based on the gamma-ray bursts (GRB) Hubble diagram, the probability that $R_h$ = ct is closer to the correct model is approximately 85%–96%, compared to approximately 4%–15% for the ΛCDM model [11]. Melia claimed that the evolutionary growth of primordial galaxies is consistent with the current view of the formation of the first stars, but only with the timeline provided by the $R_h$ = ct cosmology [12]. A similar view is presented in [13], which claims that high-z quasars is difficult to explain within the framework of the standard model. Instead, they can be naturally interpreted in the context of the $R_h$ = ct universe. (It should be noted that data from the James Webb Space Telescope have already made the situation extremely uncomfortable for SMC. The situation may only become worse as more data are collected.)

The $R_h$ = ct universe has provoked fierce debate and intense opposition. Regarding the extremely negative criticisms levied against it, Melia [14] states that one-on-one comparative tests between the $R_h$ = ct and ΛCDM models have been performed using over 14 different cosmological measurements and observations. In each case, the data favored $R_h$ = ct over the standard model, with model selection tools yielding a probability of approximately 90%–95% that the former is correct, versus only approximately 5%–10% that the latter is correct. In other words, the standard model without the equation of state (EOS) $p = -\rho/3$ does not appear to be the optimal description of nature. However, despite these successes—or perhaps because of them—some concerns about the fundamental basis of Melia's theory itself have been published recently. (Melia demonstrated in another paper that the Friedmann-Lemaitre-Robertson-Walker (FLRW) metric is compatible only with the EOS $p = -\rho/3$ model.)

Several alternative models of the universe have been proposed. One study [15] provides a non-exhaustive list of these models. The sheer number of alternate models is a testament to the myriad shortcomings of the SMC.

The model presented in this article shows that our 3D space is embedded in a 4D hyperspace. Several authors have speculated for various reasons that our universe may be embedded as a thin membrane in a large dimensional hyperspace. However, most of these models have been wrong about the number of dimensions actually needed (due to a misunderstanding of imaginary numbers) and assumed that at least five dimensions are necessary. Some such models are as follows.

Gogberashvili considered the universe as a bubble expanding in a five-dimensional spacetime [16]. This model is supported by at least two observable facts. First, each galaxy is moving away from all other galaxies, according to Hubble's law, which is easily explained by the expansion of a bubble universe. Second, there is a preferred frame in the universe from which the cosmic microwave background (CMB) is isotropic. Rubakov et al. [17] discussed the possibility of solving the cosmological constant problem by increasing the number of spatial dimensions (which creates an embedment). Van de Bruck et al. [18] provided a brief overview of the brane world idea, according to which the standard model particles are confined on a hypersurface, which is embedded in a higher-dimensional spacetime (called the bulk). Some other examples of brane world (embeddings of 3D space) are provided in the above-mentioned *alternative models of the universe* paper. The brane idea is also supported by the fact that both gravity waves and electromagnetic waves (both of which can travel through what we call "empty space") are transverse rather than longitudinal waves. Transverse waves are generally associated with a string or a membrane/sheet embedded in a higher dimensional space.

[Before rebutting the membrane model of the universe, or before claiming that evidences and observations points against any embedment in a higher dimension space, readers should kindly note that most of the objections (like absence of infinite towers of particles required for validation of Kaluza-Klein theory, which is a brane theory in a higher dimension embedment) are based on wrong assumption of Oscar Klein. His analogy of embedment in a higher dimensional space with a hose-pipe has pushed physics away from a miraculous unification to a blind alley. A hose pipe (which can be approximated as a 1D line) is embedded in a space which has two higher dimensions instead of being embedded in one higher dimension. This can be easily seen by taking a planar cross-section of the hosepipe. There is indeed a circle at every point in SpaceTime just as Oscar Klein had imagined. But this is not a physically curled-up dimension. The circle arises due to the imaginary number present in the space-time equation, and from the physical movement of the 3D hypersurface. The Euler's formula establish a relation between a circle and an imaginary exponential function.]

The model presented in this manuscript is the hyper-balloon model of the universe. Since the discovery of Hubble's law, scientists have speculated that the analogy of an expanding balloon best describes the shape of the universe. This view gradually became less popular, although it is still used for educational purposes (but not presented in any serious scientific research). Xu et al. [19] draw an analogy between the expansion of a spherical balloon surface (representing 3D space) and cosmic expansion. It examines the meaning of Hubble's law and the variation of Hubble's constant with time. They also examine the motion of objects moving on the surface of this balloon and conclude that an expanding balloon is a good metaphor for the expansion of the universe. The expanding balloon model is also used as a metaphor for an expanding spacetime by Zendri et al. [20a]. Chanda Prescod-Weinstein has claimed that the balloon analogy for an expanding universe is almost perfect [20b].

The expanding balloon model was gradually ignored and replaced by the currently accepted model of a flat and infinite universe [21–23], which is shown in this study to be based on false assumptions.

An analysis of CMB spectra [24] using Planck satellite data now favors a positive curvature of the universe (rather than flat) with a confidence level greater than 99%. It also argues for a closed universe, which can naturally explain the anomalous lensing amplitude and removes a well-known tension in the Planck dataset. In short, Planck power spectra favor a closed universe. A cosmological crisis is being masked under the assumption of a flat universe.

The Planck 2018 studies [25] have received Bayesian betting odds of over 2000:1 against an open universe and over 50:1 against a flat universe, which has serious negative implications for the SMC.

The analysis of astronomical data suggests that the universe is finite [26]. It should also be noted that at least two solid scientific arguments strongly favor a finite universe. The first relates to a thought experiment developed by Newton with two buckets partially filled with water, which demonstrated that inertia must involve a frame of reference in which distant stars and galaxies are at rest. Later, Mach concluded that the amount of inertia felt by a body must be proportional to the total amount of matter in the universe. Thus, an infinite universe would guarantee infinite inertia and make it impossible for things to move. Second, the probability of an infinite universe being created must be zero [27] because the energy required is infinite, and no quantum fluctuation can muster such a sum.

The CMB power spectrum [28] on large angular scales (for regions typically more than 60° apart) shows a strange power loss. The standard model of cosmology cannot explain this feature. If space is infinite and flat (as currently believed), then the waves created at the Big Bang would fill the cosmos at all length scales. A loss of power beyond 60° means that the broadest waves are not present, which indicates that space itself is not large enough to support these waves.

All this evidence suggests that astronomers are wrong about the shape and size of the universe. A major obstacle to deciphering the true shape and size of the universe has been the incorrect mathematical interpretation of the spacetime equations (both the Minkowski and FLRW metrics) and, in particular, the incorrect mathematical interpretation of the relative simultaneity implied by these metrics. The concept of the block universe (introduced by Einstein and Minkowski), in which there is no distinction between past, present, and future, which all exist simultaneously, is due to faulty understanding of relative simultaneity. Scientists have mistakenly used the analogy of a loaf of bread that can be sliced at different angles. The logic is that when observers are in motion, then the spacetime loaf would be cut at an angle, which means that the "now" of one observer would be significantly different from that of another. Each observer will have their own plane of simultaneity. Observers moving at different relative velocities have different planes of simultaneity. This loaf of bread analogy leads to the Rietdijk–Putnam paradox (Andromeda paradox) [29–31], which does not support this viewpoint, but only exposes it as ridiculous.

A much more appropriate analogy would be the printer cartridge analogy. Although the cartridge can only move back and forth on a 1D metal rod, it can still print any slanted line (at any angle of inclination) on 2D paper because the paper moves. The same is true if the 2D paper is held still and the metal rod moves up (or down) while the cartridge moves sideways.

An extremely important study by Dirac [32] concerning the future of cosmology has largely been ignored by cosmologists. Dirac demonstrates that there is a preferred time-axis and an absolute time in cosmology. This situation deviates strongly from the principles of relativity (both special and general), and thus, he strongly asserted that relativity would play only a minor role in the field of cosmology. Unfortunately, the currently accepted model of cosmology is based solely on general relativity (without understanding the true meaning of spacetime itself) without considering the other pillar of physics, quantum mechanics, which many physicists consider even more fundamental. The model presented in this study is fully compatible with both quantum mechanics and relativity (in fact, both arise naturally from this model), as space and time exchange roles on a tiny size scale, causing the transition from the subluminal realm (the classical world of GR) to the superluminal realm (quantum mechanics). However, those concepts require a separate study; therefore, they are not addressed in this article. Dirac's paper also points out that the radiation pressure in the universe is negligible and hence that Friedmann's assumption of a cosmic fluid in which mass density and radiation pressure are both major players needs to be re-examined.

The rest of this paper is organized as follows. In Section 2, the true physical meaning of SpaceTime is discussed and it is shown that a wrong mathematical interpretation of spacetime equations is presently accepted. Rectification of that mistake leads us to deduce the true shape and size of our universe. To gain confidence in the model here presented of the universe, the mathematical calculations are checked. In Section 3, objections against this model are addressed individually and found to fail. It is shown that our universe is not infinite in extent. Even the size of our observable universe is found to have been overestimated. The consequences of the presented model (like rest-mass momentum, which can simplify and unify physics) are discussed. Finally, in Section 4, the extremely problematic Big Bang *singularity is addressed, and this model is found to overcome that previously insurmountable problem as well. [*A singularity is a hypothesized point (zero dimension) in which the density of matter and radiation would be infinite, and the temperature would also be infinite. Big Bang singularity is also called the initial singularity, and is predicted by some models of the Big Bang theory.]

**2. Materials and Methods**

Spacetime is the arena where everything occurs and is the fabric that comprises the universe. Therefore, an accurate picture of spacetime is crucial to unraveling the shape and size of the universe.

The Minkowski-Einstein spacetime equation

$$\boldsymbol{ds^2 = (ic\,dt)^2 + dx^2 + dy^2 + dz^2 = (ic\,dt)^2 + dr^2}\,, \tag{1}$$

which explains all of special relativity, including time dilation, length contraction, and relative simultaneity, is not a statement about a 4D spacetime continuum (because imaginary numbers ***i*** cannot be used as an independent axis, as explained in **Appendix B**). The manner in which imaginary numbers are represented in the standard Argand diagram (taught in schools worldwide) is incorrect. One must correct the way negative numbers and imaginary numbers are represented.

Imaginary numbers are ubiquitous in quantum mechanics and spacetime physics. The imaginary number ***i*** enters through the temporal dimension and makes the spacetime metric (–, +, +, +) instead of (+, +, +, +). Although mathematicians correctly identified that ***i*** (the square root of –1) represents a rotation of 90° [33], scientists did not recognize that the imaginary sign (***i***) must disappear if a perpendicular axis (additional dimension) is explicitly used. The imaginary sign ***i*** can remain only as long as one does not use an additional axis. Imaginary numbers are required only for an inaccessible higher dimension. [**Please see Appendix B**].

The assumption of a 4D spacetime continuum leads to a block universe where there is no distinction between the present, the past, and the future. Minkowski and Einstein made this mistake. Our daily experience, as well as numerous scientific observations, are in stark contrast to the block universe view. The number of contradictions is so great that an entire book has been written to illuminate this glaring error [34]. Some readers might argue that experiments support the block universe view.

What those experiments validate is the Minkowski SpaceTime equation, which however is not a mathematical statement for a block universe: the mathematics is telling something else.

***2.1 The true meaning of Minkowski spacetime***

The equation

$$ds^2 = (ic\,dt)^2 + dx^2 + dy^2 + dz^2 = (ic\,dt)^2 + dr^2 \qquad (2)$$

represents a dynamic 3D hypersheet (made up of fields and particles), which can be referred to as a 3D field-particle hypersheet (3D FPHS) moving with a velocity c along the fourth dimension in an embedding 4D hyperspace. The above statement is easy to prove. Consider an arbitrary observer located somewhere in 3D space and moving at an arbitrary velocity. Relative to itself, the observer is not moving through space ($dr$ = 0). Therefore, the above equation (if we set $dr$ = 0) becomes

$$ds^2 = (ic\,dt)^2 \qquad (3)$$

Therefore,

$$ds/dt = i.c \qquad (4)$$

Consequently, every frame of reference (FOR) reaches the same conclusion. As mentioned earlier, imaginary number is required only for an inaccessible higher dimension (i.e. an inaccessible perpendicular axis). The presence of ***i*** in the above equation clearly shows that everyone is moving with velocity c in a direction perpendicular to all of the *x*-, *y*-, and *z*-axes (this direction is an impossible direction for any observer trapped in this 3D space. Why is it an impossible direction? Let any observer try to point their finger toward the future or the past. This direction is perpendicular to any direction in which he/she can point). See **Figure A2** (**Appendix B**).

Note that the above procedure also applies to any free-falling observer in the FLRW metric (in the presence of a gravitational field) because General Relativity guarantees that the FLRW metric is also locally Minkowskian. An alternate justification can be given that the temporal part of both MST and FLRW metric are identical. One can use only the temporal part to prove that every FOR is moving with a velocity c in the fourth dimension. Therefore, the above conclusion is unavoidable.

The smartest minds of the last century determined that we are all moving through spacetime at a velocity c (the speed of light), i.e., we are moving either through space or through time or a combination of the two. However, they failed to draw the correct conclusion that every observer (or frame of reference) is moving at velocity c in a single direction (the fourth dimension) regardless of their location or velocity in the 3D space. We are all moving through the fourth dimension of (hyper) space at 1079 million km/h (670.6 million miles/h). However, it is extremely difficult to sense this motion because this direction is perpendicular to all of the *x*-, *y*-, and *z*-axes (and therefore an impossible direction for humans). Moreover, everything (including the desk, chairs, buildings, gardens, and trees) move together, giving no feeling of relative motion. Before rebutting this statement, one must ask oneself the question “Can anyone sense that the earth is moving around the sun at a tremendous speed?”

Any frame of reference can only come to the same conclusion if the entire 3D hypersurface (which is mistaken as 3D empty space, or 3D vacuum) is moving in the same direction. That is why emphasis is placed on 3D FPHS (instead of 3D space) in this article. A 3D space moving through a 4D hyperspace makes no sense. Alternatively, a 3D FPHS moving (with velocity *c*) through 4D hyperspace does make sense.

Therefore, the physical meaning is clear: 3D space is a 3D hypersurface embedded in 4D hyperspace. What is this 3D hypersurface made up of? It consists of fields and particles (which are only excitations/resonances in that field). This is just the core statement of the amazingly accurate quantum field theory [35–37]. Therefore, what we call 3D space turns out to be a 3D FPHS. Laughlin mentioned that particle accelerators have definitely proven that space is more like a solid block of glass than the perfect void that scientists had previously imagined [38]. It is composed of material that is invisible but can be made visible if it is hit sufficiently hard to knock bits out. Therefore, the modern concept of the *vacuum of space* is like relativistic ether, confirmed by numerous experiments. However, scientists are afraid to describe it that way because it is taboo. The same view is taken by Sorli and Celan [39], who claim that the idea of empty space has harmed physics for more than a century and must be banished to reintroduce the ether into physics. Clearly, Einstein's logic for banishing ether from physics based on the constancy of the speed of light for every observer is incorrect. That postulate would be satisfied simply if the MST equation holds. As already seen, special relativity and the MST structure are all about being trapped in the dynamic hypersurface (3D FPHS) but free to move along the hypersurface in any three mutually perpendicular directions. Therefore, special relativity itself tacitly brings ether back into physics. Readers might wonder if Einstein ever considered how electromagnetic waves could travel through an absolute vacuum. Besides, why should an absolute vacuum have measureable physical properties like permittivity and permeability?

The lack of understanding of $i$ = sqrt(–1) led scientists to conclude that the velocity of the 3D FPHS (ds/dt = $i$.c) was imaginary, and they were therefore discouraged from digging deeper. They simply found it more convenient to conclude that our spacetime is very peculiar (hyperbolic), without questioning why this peculiarity occurs in the first place.

The possibility of a dynamical three-space has been explored by Cahill and was backed up with some solid arguments [40].

It is not easy to see what a great achievement the concept of a dynamical 3D hypersurface is unless one is intimately conversant with the intense debate that has raged for well over a century about the dimensionality and meaning of spacetime, and which is far from over [41–49]. Several papers [46-48] are sufficient to convince the reader that a non-dynamic space (non-dynamic 3D FPHS) is a mathematical impossibility.

How can everything we observe (including huge boulders, mighty mountains, and even our rock-solid planet) be just an extremely thin (hyper) surface? The answer is, it is extremely thin along the fourth dimension and not along the other three dimensions. Regarding the solidity of mountains, quantum mechanics provides the answer. One thing that quantum mechanics has taught us is that the solidity (rigidity) of rocks and the reality of everything we observe is a mere illusion. Niels Bohr famously said, "Everything we call real is made of things that cannot be regarded as real." Indeed, high-energy particle physics must abandon the idea of a particle in favor of a field [50]. A planet or a star looks like a spherical ball to us. However, to a divine being (God?) who has access to the fourth dimension, it looks like a very thin circular coin stitched in a thin membrane. Even the mightiest mountains are extremely pliable/flexible when viewed from the fourth dimension.

Although we already know that our entire 3D space (which we also call a vacuum) is filled with fields, bursting with energy (in which particles can be created and annihilated spontaneously), we have never figured out that it is this 3D FPHS that makes our geometry 3D. That is because the stars, the planets, and even we ourselves are ultimately made up of particles, which are merely resonances/excitations in the 3D hypersurface of fields. Hence, everything we observe is destined to be eternally trapped in 3D FPHS. This is a great trick of nature because the geometry of nature is 4D (i.e., 4D hyperspace). Space (actually, hyperspace) is nothing but a 4D geometry (true vacuum) embedding this 3D FPHS. Imagine a 2D living being that can only move on the surface of a 2D rubber sheet (RS). If the RS is absolutely transparent or invisible and offers no resistance to its motion (unless it changes velocity), the creature will assume that the RS is the space/geometry of the universe itself. It will treat the RS as synonymous with empty space in such a way that it will consider the distance between two visible points on the RS as spatial distance, even if the RS is curved and the line joining the two points happens to be a curved line. Even if it is somehow aware of the existence of the (almost imperceptible) RS, it will ignore its presence and hardly ever take note of the fact that it is a trapped entity. For the purposes of this research, it believed with certainty that this situation is indeed the case.

The simple fact that Einstein mistook this (dynamic) 3D hypersheet for the fabric of 4D spacetime continuum becomes very clear when we investigate the 1995 proposal by Jacobson that Einstein's gravitational equations can be derived from thermodynamics [51]. This concept suggests that gravity is just an average of the behavior of unknown "atoms" of spacetime (rather, not spacetime but the field-particle hypersheet).

The embedding 4D hyperspace is absolute and Euclidean (as it should be) and possibly extends infinitely in all four directions. The void/nothingness may be infinite, whereas our universe (which is shown in the subsequent sections to be shaped like a balloon) is finite and closed. Newton's concept of absolute space has been restored. Newton would surely be proud. Indeed, we need absolute space to explain both inertia and acceleration. Relativity is all about being trapped inside a dynamic 3D FPHS (but being free to move in any three mutually perpendicular directions inside the hypersurface), while the 3D FPHS itself is embedded in an absolute 4D hyperspace. This solves the conflict between Newton and Einstein. We need to look out through the window of a moving car to determine whether it is moving or at rest (Einstein's view), but we can tell with our eyes closed whether the driver has pressed his foot on the accelerator and is therefore accelerating with respect to an absolute space (Newton's view).

The Minkowski spacetime equation (MSTE) can also describe a small section of an expanding (hyper) balloon. In this case, the outward movement (along the radius of the hyper-balloon) of the small section plays the role of the movement along the fourth dimension. The MSTE is a perfect description of an infinitesimally small section on the 3D hypersurface and describes the motion of this point along the fourth spatial dimension. However, it neglects the expansion (stretching) of the hypersurface of the (hyper) balloon that accompanies this motion along the radius of the (hyper) balloon. An analogy to a party balloon makes this situation clearer. As the balloon expands, two things happen simultaneously. 1) A point on the wall of the balloon moves away from the true center of the balloon along the radius of the balloon. 2) Nearby points appear to move farther away from that point due to the stretching of the wall of the balloon.

A more general treatment is provided by the FLRW metric (instead of the MST metric) that includes a scale factor $a(t)$ that accounts for this spatial stretching. The FLRW metric is

$$\boldsymbol{ds^2 = -c^2 d\tau^2 = (ic\,dt)^2 + a(t)^2 d\Sigma^2} \tag{5}$$

where Σ extends over a 3D space with uniform curvature (this can be an elliptic, Euclidean, or hyperbolic space). It is written as a function of three spatial coordinates, usually in terms of spherical coordinates, but can also be written in Cartesian coordinates. Σ does not depend on time ($t$). All time dependence is taken care by the function $a(t)$, which is known as the scale factor.

[**Note:** FLRW metric is unnecessarily complicated for physical purposes, because it includes all three possibilities of curvature (i.e. positive, negative and zero curvature) that are mutually exclusive. It has been accepted in that way because of lack of conclusive knowledge about curvature. Soon Euclid telescope or the DESI (Dark Energy Spectroscopic Instrument) team can conclusively tell about the curvature from the 3D map of the universe they are creating.]

The FLRW metric takes care of both the above mentioned points: 1) the temporal part of the above equation says that "A point on the wall of the balloon moves away from the true centre of the balloon along the radius of the balloon." 2) The second part of the above equation says: "Nearby points appear to move farther away from that point due to the stretching of the wall of the balloon." It accounts for the observed Hubble's law.

**Note:** The validity (or even the mathematical correctness) of the Minkowski metric and the FLRW metric is not challenged in this paper. However, the physical meaning is challenged, and shown to be different from the presently accepted ones.

### *2.2 Deducing the true shape and size of the universe*

Another major obstacle in determining the true shape and size of the universe is the belief in a flat universe. The concept of a 3D flat universe is the main reason for the introduction of cosmic inflation theory, which has been criticized in an astonishing number of publications [52–56].

Cosmologists are convinced that they have measured the universe to be (3D) flat by two different methods:

a) summation of plane angles in a triangle method

b) critical mass-energy density method of GR.

(The meaning of 3D flat can be understood by an example. The surface of a tabletop and the surface of a sphere (football) are both 2D. However, the surface of a tabletop is flat, whereas the surface of a sphere is curved in the third dimension. A flat surface obeys Euclidean geometry, whereas a curved surface does not. Humans can only imagine three dimensions. However, there is a fourth dimension, as shown by Minkowski. Therefore, 3D space can be considered as a 3D hypersurface in a 4D embedding hyperspace. The 3D hypersurface will be flat if it is not curved in the fourth dimension.)

Unfortunately, neither method can measure the extrinsic curvature of a 3D hypersurface.

1) The first method relies on checking whether the sum of the plane angles of a triangle formed by two points at opposite ends of a CMB spot (whose size is known) and the point on the measuring instrument is 180° or greater than 180°.

*Note: The actual analysis of CMB for testing the flatness of the universe is based on the full 2D pattern of cold and hot spots of the cosmic microwave background decomposed into spherical harmonics, in which the statistical properties of the observed universe are compared with the model predictions. However, it is still based on the summation of the plane angles of a triangle*.

Checking the curvature or flatness of a surface by examining whether the sum of the plane angles of a triangle (drawn on that surface) is 180° or greater works well for a 2D surface that curves in the third dimension (e.g., the surface of a ball). However, when checking the curvature of the universe, one is talking about a 3D hypersurface (i.e., 3D space) that curves in the fourth dimension. What one needs is a tetrahedron, the sum of whose solid angles should be checked. The following is the reason that using the sum of plane angles of a triangle is bound to fail.

Let us go down from a 3D hypersurface to a 2D surface, using the curved surface of the Earth as an example. Suppose that a person starts from point A at the North Pole and moves south to point B on the equator, then moves an equal distance along the equator to point C and turns 90° to face north, then continues their journey to reach point A again. Now each of the angles at A, B, and C is 90°. Therefore, the sum of the angles in the triangle is 270° (see **Figure 1**).

Now they repeat the journey from point A (North Pole) and again reach point B on the equator. However, this time they travel only a few steps and turn 90° again. They continue the journey to reach point A. Now the angles formed at points B and C are both 90°, whereas the angle formed at A is almost 0°. The sum of the angles is now almost 180°.

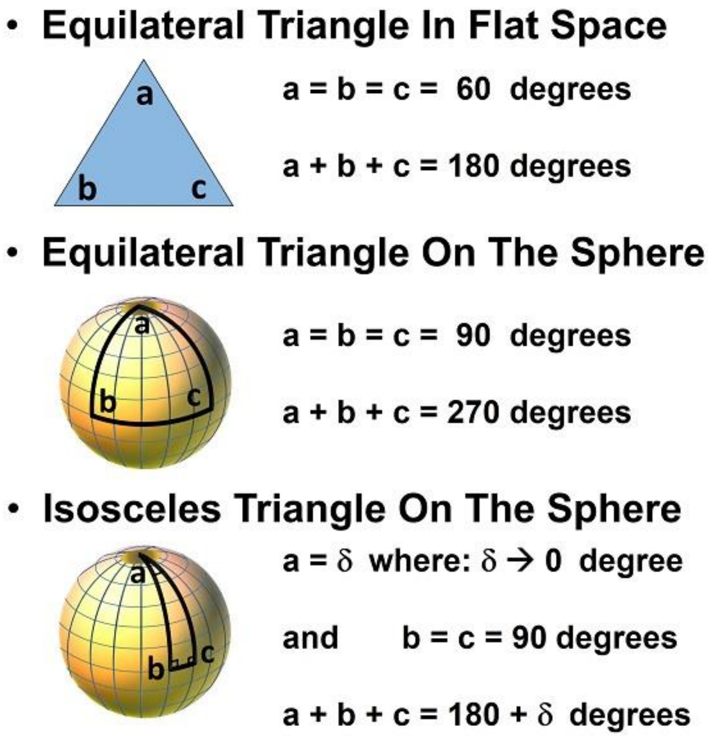



**Figure 1.** Triangles on flat and curved surfaces.

Thus, if the triangle shrinks to a line (i.e., point C approaches and eventually merges with point B), it loses its detecting power. One needs a 2D object (like a triangle) and not a 1D object (a line) to measure the curvature of a 2D surface. The same logic applies to a higher dimension. A triangle is nothing more than a tetrahedron with its apex/peak point merged to its base. Therefore, a triangle is useless for measuring the curvature of the universe.

2) The second method of measuring the curvature of our universe relies on the critical mass-energy density method of General Relativity (GR). However, GR uses the modified MST metric (although it uses complicated tensor calculus) and thus reflects the viewpoint of a creature trapped inside three

dimensions with no access to free motion along the fourth (time) dimension. Both special relativity and GR assume that time itself is the fourth dimension, which is certainly NOT the case, as time does not have the units of meters, feet, yards, or miles. Relativity fails to account for the motion of the 3D hypersheet (which is assumed to be synonymous with 3D space). Time results from motion along the fourth spatial dimension (which makes sense as time has the unit of $\frac{\boldsymbol{Distance\ (meter)}}{\textbf{Speed}\ (\frac{\textbf{meter}}{\textbf{second}})}$ ). There is no concept of “outside” in GR because it is an intrinsic viewpoint (i.e., the viewpoint of a creature trapped in the moving 3D hypersheet), and consequently GR can measure intrinsic but not extrinsic curvature. The difference between intrinsic and extrinsic geometry is that intrinsic geometry describes curvature without requiring a higher dimension (which is the case with GR), whereas extrinsic geometry requires a higher-dimensional embedding space to describe curvature. This situation is precisely why GR cannot predict the global structure of the universe, nor can it account for the “external field effect,” which has now been confirmed to 11σ accuracy in galaxies [57]. Therefore, GR can be compared to the perspective of a goldfish in a round glass jar. Its viewpoint is not wrong, but it is highly distorted and inferior to that of a human being outside the jar.

Therefore, one cannot be sure that the universe is 3D flat. However, how can one be sure that it is curved? Here is another clue that cuts to the heart of the matter: Our universe has a center, although the center does not lie anywhere in our 3D space [which is actually a 3D hypersheet composed of fields and particles, i.e., a 3D Field-particle HyperSheet (3D FPHS)]. This concept can easily be proven.

The center of mass equation is a powerful equation:

$$\boldsymbol{c.m.} = \frac{\sum_{i=1}^{n} \boldsymbol{m_i}\, \boldsymbol{r_i}}{\sum_{i=1}^{n} \boldsymbol{m_i}} \tag{6}$$

where $\boldsymbol{m_i}$ is the mass of the point particles and $\boldsymbol{r_i}$ are the space coordinates of the point particles.

In the vastness of our cosmos, each galaxy (or a cluster of galaxies) can be considered as a point mass. Even when the number of galaxies ($n$) tends to infinity ($n \rightarrow \infty$ ), there remains a single point as the center of mass. The mere invocation of infinity will not dissuade anyone from the conclusion that there is indeed a center. Further, it must lie outside of the 3D hypersurface. Otherwise, the true center could have been located, and Hubble’s law would not have the special form $v = H_0D$. Also, the Big Bang would not have appeared to have occurred everywhere. In fact, the cosmos would be an irregular structure consisting of an empty central region (the “crater of the explosion”), an intermediate region containing the galaxies, and an external part containing only radiation. No structure in 3D space formed from an explosion 13.8 billion years ago could resemble the universe we observe today.

There is another reason that 3D space (3D FPHS) must be curved. Let us assume that both 3D flat and 3D curved shapes are possible and consider which of the following two models is correct. Two conditions need to be satisfied. 1) The 3D hypersheet moves in a single direction (along the fourth dimension). 2) Hubble’s law implies that the entire 3D FPHS is stretched as each galaxy moves away from every other galaxy, although there is no net motion (i.e., motion on average) of galaxies through 3D space.

From the above two conditions, it is easy to derive two different models of the universe: 1) an expanding 3D flat universe (an expanding grid model), and 2) an expanding 3D curved universe (hyper-balloon universe).

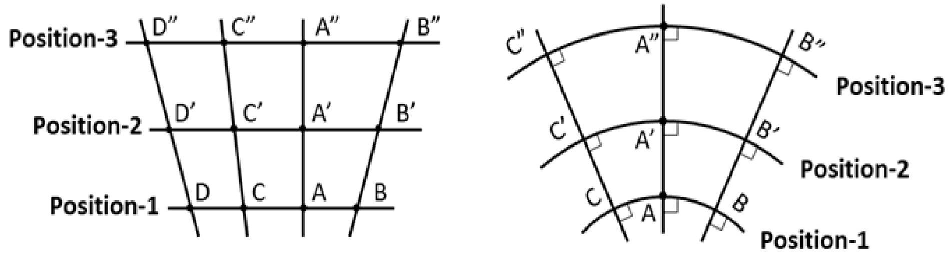



**Figure 2**. Comparison between the grid model and balloon model of the universe.

**Figure 2** shows three positions of a moving hypersheet (at various times) in both diagrams. In both cases, the hypersheet is stretched as it moves upwards (i.e., along the fourth dimension). In the hyper-balloon case, the word "outwards" might be more appropriate than "upwards." In the first case, it remains 3D flat, whereas in the other case, it resembles a section of an expanding balloon.

Now, if both conditions are satisfied, then from the first diagram, only one galaxy will move straight upward (and has no sideways movement as the 3D FPHS continues to stretch and move upward). The upward motion here represents the fourth dimension.

In fact, Hubble's law guarantees that any galaxy lying farther than the Hubble distance from galaxy A will be moving sideways at a velocity greater than the velocity of light *c*.

The equation

$$ds^2 = -c^2dt^2 + dx^2 + dy^2 + dz^2 \quad (7)$$

states that for any galaxy not moving locally, d*r* = 0 satisfies $ds = i.\mathbf{c}.dt$, or,

$$\frac{ds}{dt} = i.\mathbf{c} \quad (8)$$

This equation clearly states that it only has a velocity of *c* in the fourth (inaccessible) direction, and no lateral velocity component.

In the (flat) grid model of the universe, except for galaxy A, all other galaxies violate this equation (because they are inevitably moving sideways as well). The farther the galaxy is from point A, the greater its lateral velocity, which may be far greater than the speed of light at greater distances.

The other possibility that remains is a balloon universe, in which all galaxies can simultaneously satisfy both conditions 1 and 2, as well as (8).

Therefore, a hyper-balloon best describes the shape of the universe. However, to gain even more confidence, one must verify that the mathematical calculations for the hyper-balloon model are correct.

### *2.3 Verification: mathematical calculations for the (hyper) balloon universe model*

The formula for the circumference of a circle is 2π*r* (where *r* is the radius of the circle). Passing from 2D to 3D, the equivalent figure for a circle becomes the spherical surface of a sphere. If a great circle is drawn on the spherical surface (e.g., an equatorial line), the circumference of the great circle is still 2π*r*.

Moving from 3D to 4D, the equivalent figure for a sphere becomes a hypersphere, and thus, the equivalent figure for the spherical surface (which has the unit of area i.e. meter square) becomes the spherical hypersurface (which has the unit of volume i.e. meter cube). However, the formula for the circumference of a (hyper) great circle should remain 2π*r*. Note that the (hyper) great circle, or HGC, would be drawn on the 3D hypersurface of the 4D hypersphere.

We have assumed a (hyper) balloon model of the universe whose radius is constantly increasing at the speed of light (*c*). Taking the age of the universe to be 13.8 billion years, the radius of this model of the universe is 13.8 billion light years (distance = velocity (*c*)×time).

On the basis of the above model, the expansion rate of 3D hypersurface, which we call "our universe" can be easily calculated. At time $t_1$, let the radius of this hypersurface be *r*. At later time $t_2$, let the radius of this hypersurface be equal to *R*. The circumference of the HGC drawn on this hypersurface increases at a rate given by

$$\boldsymbol{Rate} = \frac{2.\pi.R - 2.\pi.r}{t_2 - t_1} = \frac{2.\pi.(R-r)}{\Delta t} = \mathbf{2}.\boldsymbol{\pi}.c,$$

assuming the limit $\Delta t \rightarrow 0$.

The circumference of this (hyper) great circle is 2π*R* (or 2π*r*, whose difference from the former does not matter if we take the limit $\Delta t \rightarrow 0$). To calculate the rate of expansion of this HGC per unit length of the HGC, we should take the ratio ($K_0$) = $\frac{2\pi c}{2\pi R} = \frac{c}{R}$, where *R* = 13.8 billion light years = $13.8\times10^9\times(365\times24\times60\times60)\times c$.

(Taking the value of *c* as $2.99792458\times10^8$ $ms^{-1}$, the value of radius of the universe (*R*) is approximately $1.3047\times10^{26}$ m, which is approximately the same as the value of $R_{univ.} = 1.28\times10^{26}$ m given by Mercier [58] as the apparent curving radius ($R_{univ}$) of the universe.)

Therefore, $\frac{c}{R}$ = $[13.8\times10^9\times(365\times24\times3600)]^{-1}$ $s^{-1}$ = $22.978\times10^{-19}$ $s^{-1}$

However, 1 megaparsec (1 Mpc) = $3.09\times10^{19}$ km. Multiplying this value times the value of $\frac{c}{R}$ yields the following:

$K_0$ = ($22.978\times10^{-19}$) $s^{-1}$ × $3.09\times10^{19}$ km = 71.002 km/s/Mpc.

This value (71.002 km/s/Mpc) lies between the currently accepted values of the Hubble constant (calculated by different methods) of 69.8 km/s/Mpc and 74 km/s/Mpc. As the Minkowski-Einstein spacetime equation and the Hubble law tell the same story, we should be confident that we are on the right track.

Please note that this derivation of the Hubble constant value is not intended to demonstrate any novel method for finding the Hubble constant value. It is intended to show that the temporal part of spacetime metric (both the FLRW and MST metrics) agrees very well with the actual value of the Hubble constant when a (hyper) balloon model of the universe is used. The currently accepted standard model of cosmology overlooks this crucial relationship between Hubble's law and the spacetime metric and thus cannot even explain why the Hubble constant must have the particular value that is actually observed. In fact, it completely ignores what the temporal part of spacetime metric (both the FLRW and MST metrics) implies: The entire 3D hypersurface (which is assumed to be synonymous with 3D space) is moving in a direction perpendicular to all of the *x*-, *y*-, and *z*-axes. Time results from this motion along the fourth spatial dimension, and time itself is not a dimension (because it does not have units of meters, miles, feet, yards etc.) The concept of time arises from the formula: Distance (covered) = velocity X time.

This model of the universe (a 3D hypersurface of a 4D sphere, expanding with radial velocity of *c* in a zero energy balance between motion and gravity) has been used by Suntola [59–64].

***2.4 Is c really the velocity of light? Why cannot anything move faster than c?***

The novel interpretation of the Minkowski spacetime equation shows that ***c*** is the outward expansion rate of our universe, not the velocity of light. This situation is indeed shocking, considering that historically relativity (and the concept of spacetime) had its origin in the postulate of the constancy of the velocity of light in vacuum for any observer. Thus, the question arises of how both the velocity of light and the expansion rate of the universe (i.e., the outward velocity of the 3D FPHS) can have the same value.

In fact, many other physical quantities have the same value *c*, as Ellis and Uzan [65] point out. That should have been sufficient to raise the suspicion that the velocity *c* is due to something very deep and fundamental.

Special relativity (SR) is based on the experimental fact that light travels at a constant velocity (*c*) independent of the motion of the reference frame. SR does not explain how this postulate comes about. Consequently, even after a century, SR is only a principle theory, and there is no constructive theory explaining it yet. [**Note:** There is a difference between Principle Theory and Constructive Theory. Whereas *principle theories* are about the phenomena, *constructive theories* aim to get at the underlying reality. Einstein made a distinction between principle theories like Newtonian mechanics and constructive theories like kinetic theory of gases.]

Moreover, the following questions arise. Is light somehow magical? Is relativity just a branch of electromagnetism? How is it that gravitational waves travel at the same speed of light? (Faced with such embarrassing questions, some scientists have clarified that *c* is not the velocity of light, but rather the speed of causality. In other words, it is the fastest speed at which two separate parts of the universe can communicate with each other, which clarifies the situation to an extent. However, the question of why has not yet been answered.)

One must ask these questions again. Why is the velocity of light (*c*) constant? Why cannot anything travel faster than the speed of light?

The real reason is that it is a peculiarity of Minkowskian (hyperbolic) structure. The Minkowskian spacetime equation $\boldsymbol{ds^2} = (\boldsymbol{ic\,dt})^{\boldsymbol{2}} + \boldsymbol{dx^2} + \boldsymbol{dy^2} + \boldsymbol{dz^2} = -\boldsymbol{c^2dt^2} + \boldsymbol{dr^2}$ can be re-arranged as follows:

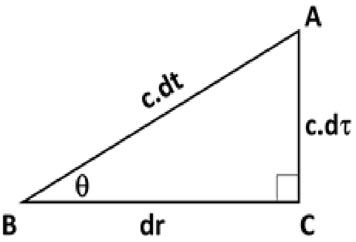
$$\boldsymbol{c^2dt^2} = -\boldsymbol{ds^2} + \boldsymbol{dr^2} = \boldsymbol{c^2d\tau^2} + \boldsymbol{dr^2}. \qquad \text{(since, } \boldsymbol{d}\text{s} = -\boldsymbol{c.d\,\tau}\text{)}$$

This formula is the Pythagorean equation (equation of a right angled triangle; Figure 3).

$$Velocity = \frac{dr}{dt} = \frac{dr}{AB/c} \ (since\ AB = c.dt)$$

$$= c.\frac{dr}{AB} = c.\ \frac{BC}{AB}$$

$$= c.\ \frac{Base}{Hypotenuse} = c.\ cos\theta$$




$$\begin{bmatrix} As\ dr \to \infty\ (i.e.\ body\ moving\ infinitely\ fast)\ ,\ \theta \to 0 \\ \Rightarrow cos\theta \to 1 \quad and \quad Velocity = c \end{bmatrix}$$

**Figure 3.** The Minkowskian (hyperbolic) structure of spacetime limits the velocity of light and gravitational waves to *c*.

Thus, here is the real reason that nothing can travel faster than the speed of light (which is actually the expansion rate of our universe).

From the above figure, the velocity is given by constant×(base/hypotenuse). Due to the Minkowskian (hyperbolic) nature of spacetime, it is imperative that any extremely high velocity be throttled at *c*. As the base (the distance travelled by the object) becomes larger, the hypotenuse also becomes larger (time dilation), because, according to the Pythagorean Theorem, the length of the base of the triangle contributes to the length of the hypotenuse.

In other words, because of this particular geometry, if the reference frame is moving fast enough, we start counting spatial distance as temporal distance. We inevitably mix space and time.

In fact, there is no speed limit in the universe (photons can travel at infinite speed). Photons can travel from one galaxy to another without feeling the ticking of time (i.e., the time dilation for the photon becomes infinite, and a clock stops for a photon). Alternatively, if we use the formula for length contraction, we can easily see that the distance between one galaxy to the next has shrunk to zero for a photon, so that it can travel instantaneously. If we use the formula for the *proper velocity* of a photon, we can easily verify that it is travelling infinitely fast. An observer moving at a velocity of 99.999% of the velocity of light (*c*) also measures the velocity of light as *c*. This situation is possible only if the velocity of light is infinite (and not with a fixed numerical value of $3\times10^{8}$ $ms^{-1}$).

***2.5 Consequences and justifications of the method used***

If we ignore the dynamical nature of the 3D FPHS—in other words, ignore what the temporal part of the MST equation tells us (which seems natural to trapped beings like us)—then our world indeed appears 3D and Euclidean $\boldsymbol{ds^2 = dx^2 + dy^2 + dz^2}$, just as Euclid himself stated.

An immediate consequence of the correction (4D spacetime continuum versus dynamic 3D FPHS) is that one dimension becomes free (which we had unnecessarily reserved). Kaluza’s miracle of obtaining Maxwell’s equations in addition to Einstein’s field equations [66] seemed to exact a heavy price: A fifth dimension was needed as an embedding space. However, four dimensions suffice (and we obtain electromagnetic phenomena as a bonus). In fact, the effects of freeing up a dimension are much more profound and resolve the demand for a fifth dimension that appears everywhere in physics [67–72], but the strict limitation of the number of dimensions to four, which follows from experiments and observations, simply does not allow a fifth dimension [73].

The following objections that could be raised against the presented model of the universe all fail miserably.

The presented model is in conflict with the measured flatness of the universe from the CMB using the summation of angles of a triangle. (# It has already been explained that we need a tetrahedron, not a triangle).

This model is also in conflict with the accelerated expansion of the universe, as claimed in currently accepted ΛCDM model of the universe, because a constant rate of expansion has been claimed in this study. [# More recent studies using a much larger amount of data actually favour a constant rate of expansion of the universe over an accelerated expansion. This finding, along with the theoretical justification (based on proper interpretation of SpaceTime equation) for a constant rate of expansion of the universe (as provided in this paper) solves the problem of *dark energy*. We do not need dark energy because we do not have to account for such acceleration.]

The observable universe is itself 94 billion light years across, so the entire universe must be much larger. [# This argument also fails (this point is explained two paragraphs hence).]

Nielsen et al. [74] shows that the available data (from Type Ia supernovae) are still quite consistent with a constant rate of expansion of the universe. Kindly note that this conclusion was drawn from a much larger database of supernovae than those studies that claimed an accelerated expansion of the universe. The evidence for the existence of dark energy has again been challenged by Mohayaee et al. [75], whose analysis used a much larger sample of 740 SNe Ia than that of the original study of 93 Type Ia supernovae from which it was claimed that the universe is accelerating. The existence of dark energy and accelerated expansion of the universe has also been questioned by Nadathur and Sarkar [76], Colin et al. [77], and Sarkar [78]. Kipreos [79] has shown that after adjusting for the effects of time contraction on a redshift–distance modulus diagram, a linear distribution of supernovae across the full redshift spectrum consistent with a non-accelerating universe is obtained.

This explanation is further supported by Vavryčuk [80], who show the standard FLRW metric creates the illusion of dark energy through supernova dimming.

## 3. Results and Discussion

### *3.1 Overestimation of the size of the observable universe.*

[An assertion was left without a proper explanation: How can the universe have a radius of 13.8 billion light-years, when the observable universe is itself 94 billion light years across?]

Bikwa et al. [81] and Li et al. [82] both present arguments that astronomers have greatly overestimated the size of the observable universe. Bikwa et al. claim that the Hubble radius (approximately 13.7 billion light years) is the limit of our observability, even though it is commonly claimed that objects in the Hubble radius have a redshift of only approximately 2, whereas the CMB has a redshift of approximately 1100. Li et al. claim that the earliest observable cosmic radius $R$ ($t_{earliest}$) is always 0.368 $R$ (where $R$ is the current cosmic radius), and therefore the farthest observable distance is always $R$ – 0.368$R$ = 0.632$R$.

The logic (often presented in textbooks) in favor of the observable universe being larger than the Hubble Sphere is the following:

The Hubble constant decreases with time (this is true).

In this way, the Hubble distance increases with time (this is also true).

As the Hubble distance increases, galaxies that were originally outside the Hubble distance and receding from us come inside the Hubble distance (this is where the problem begins).

Imagine a galaxy G1 located exactly on the surface of the Hubble sphere at an early time. Imagine another galaxy G2 lying a little farther away.

At a later time, the Hubble distance has increased. However, the distance between us and galaxy G1 has also increased in exactly the same proportion due to stretching of space (therefore galaxy G2 has not yet entered the Hubble sphere). The photon moving towards us would be running on a treadmill due to the expansion of space itself. Using the balloon model of the universe, it is easy to see that the Hubble radius always remains the same as the actual radius of the universe.

Let us assume that the age of our universe is *T*. Because the radius of our universe is expanding at a constant velocity *c*, the current radius would be *cT*.

As we have seen, the Minkowskian structure of spacetime limits the value of the speed of light at *c*. Therefore, the distance traveled by a photon (Hubble distance) = *cT*

[The fact that our universe was opaque right after the BB due to the strong coupling of radiation and matter is ignored. About 380,000 years later it became transparent, so the farthest distance we can see is slightly reduced. Therefore, the actual size of the observable universe is slightly smaller. However, 380,000 years is quite small and negligible compared to the age of the universe.]

A Hubble distance on the hypersurface of the (hyper) balloon universe always forms an angle of 57.2956° at the true center of the universe, which is the BB center.

The claim that the observable universe is much larger than the Hubble sphere is not correct.

The following question was posted on the University of California, Los Angeles website https://www.astro.ucla.edu/~wright/cosmology_faq.html#DN

"If the universe is only 14 billion years old, how can we see objects that are now 47 billion light years away?"

The explanation offered for the question begins with the formula for the radius of the observable universe, which it claims is

$$\int_0^{t_0} (\boldsymbol{t}/\boldsymbol{t_0})^{-2/3} \, c \, dt = 3c \, \boldsymbol{t_0} \qquad (9)$$

The simplified explanation stated that another way to look at this situation is to consider a photon emitted by a galaxy that is now 42 billion light years away from us, 14 billion years after the BB. The distance of this photon satisfies the condition $D = 3ct$. If we wait 0.1 billion years, the universe will grow by a factor of $(14.1/14)^{2/3} = 1.0048$, so the galaxy will be 1.0048×42 = 42.2 billion light years away. However, the light will have traveled 0.1 billion light years farther than the galaxy because it is moving at the speed of light relative to the matter around it and will thus be at $D$ = 42.3 billion light years, so $D = 3ct$ is still satisfied.

This reasoning is flawed because it assumes that the photon does not have to reach our eye/telescope for the galaxy to be visible. We need to consider a photon (emitted by that galaxy) which is traveling *not away from us, but toward us*. Consider a photon emitted by the galaxy toward us. After 0.1 billion years, the galaxy will be 42.2 billion light-years away from us. In the meantime, the photon has travelled 0.1 billion light-years toward us, and is thus at a distance of 42.1 billion light-years from us.

It started with a distance of 42 billion light-years and after 0.1 billion years it is now 42.1 billion light-years away from us. The more time passes, the farther the distance will increase. Can the photon ever reach us at this rate?

The simplified explanation was trying to justify the claim that more and more galaxies located at ever farther distances from us are entering our observable sphere as time passes by. But it was conclusively shown that this cannot be the case because light (photon) emitted from those galaxies will fail to reach us even if one waits till eternity.

(A literature search on cosmology reveals that two mutually contradictory claims are made in the textbooks. 1) Ever more galaxies will enter the observable sphere as time passes. 2) Ever more galaxies will recede away from the boundary of the observable sphere over time.)

### ***3.2. Implications of the presented model of the universe***

Physics and cosmology are intimately related (e.g., conservation laws of physics arise from the symmetry of nature, as stated by Noether's theorem). Using this simple shape of our universe, we can directly see why these symmetries (e.g., homogeneity and isotropy) arise in the first place. The model of the universe presented resembles a balloon, or rather, a hyper-balloon. The surface of the balloon looks same everywhere (homogeneous), and from any point on the surface, all directions (along the surface) look basically the same (isotropic). That explains the origin of the crucial conservation laws of physics (via Noether's theorem).

It is well known to physicists that absolute simultaneity (rather than relative simultaneity) is required by the *Sagnac effect*, whereas quantum mechanics requires absolute time. From the perspective of the center of the universe, simultaneity is absolute and there is also absolute universal time. That is because the absolute universal time since the Big Bang is just a function of the radius of the universe. From our viewpoint (located at an awkward peripheral position in the universe), locality is absolute, velocity *c* is the upper limit and remains constant for every observer. Those were Einstein's firm beliefs, which were later shattered by quantum entanglement experiments (which led to the award of a recent Nobel Prize). This viewpoint turns (our) space and time into inseparable twins and makes (our) time a relative concept. The existence of both absolute time and relative time partially solves the *time problem* which has so stubbornly resisted the reconciliation of quantum mechanics and General Relativity. In fact, moving the viewpoint to the true centre of the expanding universe explains the origin and true nature of time itself. The radial expansion of the universe appears as passage of time from our perspective. That is because from our viewpoint, the radius of the universe is an impossible direction, which does not even exist for us (thus forcing us to use imaginary numbers) and hence it is a temporal dimension. There is one more point that needs to be discussed regarding this model of the universe. The (entire) closed universe is an absolutely isolated system (True Island) in which total spin, total momentum, etc., must be conserved, however small the magnitude may be. This situation gives rise to non-locality and instant communication over vast distances in quantum-entangled particles. Any open and infinite model of the universe cannot offer a satisfactory explanation of quantum entanglement (which has now secured a firm place in physics and shows no likelihood of being overturned).

### *3.3. Rest-mass momentum*

Another consequence of the dynamic 3D FPHS is the concept of rest-mass momentum, which is expressed as

$$P_{rest} = m.c \tag{10}$$

This concept makes the physics simpler and more consistent (and leads to a unification of the concept of momentum so that we do not have to resort to two sets of rules for calculating the momentum of massive particles and of photons).

This concept was proposed by Haug [83], but without an explanation why. For a dynamical 3D FPHS (moving at velocity *c*) and dragging any matter along with it, this concept is built in and integral to the theory. We have never thought about rest-mass momentum because we are moving along with the mass (that we are considering) at the same velocity and in the same direction (hence the relative velocity is zero). However, from the perspective of nature (i.e., from the viewpoint of the center of the universe), the mass *m* is travelling with velocity *c*.

Therefore,

$$\boldsymbol{Momentum\ (p) = mass\ (m).velocity\ (v) = m.c} \tag{11}$$

and as explained by Haug, the energy is always

$$\boldsymbol{Energy(E) = Momentum\ (p).c} \tag{12}$$

Therefore, rest mass energy is as follows:

$$\boldsymbol{E = mc.c = m.c^2} \tag{13}$$

That is the true reason for the origin of rest mass energy. We might not have accepted the concept of rest mass energy ($\boldsymbol{E = m.c^2}$) if we had not observed nuclear reactions.

This model is also consistent with other observations, such as the following.

The surface of a 4D hypersphere is 3D and unbounded (we cannot find an edge to our model universe), just like our own universe. As stated already, it agrees with the cosmological principle that our (3D) universe is homogeneous and isotropic, which guarantees that Noether's theorems are satisfied.

It seems that there is no centre of the universe (although there is indeed a centre) and also that the BB seems to have happened everywhere. This model explains naturally why the BB was not an explosion of matter in 3D space, but rather an explosion of space itself. Objects such as galaxies and galaxy clusters in our universe do not move through space (on average), they move with space. Of particular importance is the form of Hubble's Law, which shows that everything is moving away from everything else, as if every object is at the centre of the universe. This concept fits with this model very well.

The currently accepted SMC does not provide a satisfactory answer to the following question: If the universe is expanding, what is it expanding into? GR assumes that the metric tensor is changing (an analogy is a 3D grid, where the distance between each intersection points of the grid is increasing), but the universe is not expanding into anything. However, this concept is illogical, as the distance between the individual points increases without the overall space (which contains all these points) expanding into anything. The present model gives a satisfactory answer to the above question. Our balloon universe (the term universe is used only for the 3D balloon surface) is expanding into a 4D hyperspace, which could extend infinitely in all four directions. i.e., the hyperspace (void) is possibly infinite, while the matter and fields (the wall of our hyper-balloon universe) have a finite extension and form a closed hypersurface.

### *3.4. Rethinking the BB singularity*

The BB model is problematic because if someone let time run backwards and rewound it arbitrarily, then a singularity would inevitably be reached in which the density of matter/radiation would be infinite, and the temperature would also be infinite. Everything that exists in the universe today would be confined to a single point, which means a complete breakdown of known laws of physics.

If there had been a singularity in the history of the universe, there would be many observable signatures today. The residual glow of the BB would have temperature fluctuations with enormously large amplitudes. However, the temperature fluctuations are only 1 in 30,000 parts of what the BB singularity would predict. In addition, there would have been copious numbers of magnetic monopoles and other ultra-high energy relics. The constraints imposed by the observations are incredibly tight, so a BB singularity can be ruled out with certainty. This fact strongly suggests that there is indeed a limit to how far the clock can be turned back. One cannot extrapolate to a singularity.

This problem arises primarily because GR is the inside view of a being trapped in 3D space (i.e. being trapped in the 3D hypersurface of a 4D hypersphere). Consequently, GR has no concept of the outside, or even a concept of an embedding 4D hyperspace. However, as shown in this study, the spacetime metrics (both the MST and FLRW metrics) are mathematical statements for embedment of the 3D FPHS, which we call 3D space, in 4D hyperspace.

Because GR has no concept of embedding, it also lacks the concept of the thickness of this 3D FPHS. Therefore, GR does not recognize that a balloon wall necessarily becomes thinner as the balloon expands and increases its surface area. If the process is reversed (i.e., the balloon deflates), then the wall becomes thicker and thicker.

Imagine a (rubber) football with a certain wall thickness. As the football deflates, the walls become thicker. However, this process cannot continue indefinitely until the football disappears into a single point. Eventually the wall will become so thick that the inner surface of the wall will converge upon itself (in other words, the empty space inside the football will disappear). The football will then resemble a solid cricket ball.

In 3D, the volume of a sphere is given by $(4/3).\pi.R^3$ and the area of the surface of the sphere is given by $4.\pi.R^2$. In 4D, the (hyper) volume of the (hyper) sphere is given by $(1/2).\pi^2.R^4$ and the volume of the spherical (hyper) surface is given by $2.\pi^2.R^3$. Assuming that the spherical (hyper) surface has uniform thickness $\Delta x$ everywhere, the (hyper) volume is given by $2.\pi^2.R^3.\Delta x$.

Further assuming that the hypervolume has remained constant throughout the history of the universe (similar to the case where the amount/volume of rubber in an expanding or deflationary balloon remains constant), the equation to be satisfied is

$$(1/2).\pi^2.(R_i)^4 = 2.\pi^2.(R_f)^3.\Delta x . \quad (14)$$

The subscripts *i* and *f* denote the initial and final (present) radius of the universe. The present radius is approximately $1.30468718385\times10^{26}$ m, which gives

$$(R_i)^4 = 8.88339922756\times10^{78}\times\Delta x . \quad (15)$$

The value of $\Delta x$ can be estimated from two different sources. In the course of my research (not yet published), I found that the value of Planck's length is itself determined by the thickness ($\Delta x$) of the 3D FPHS. Hence, $\Delta x$ should be of the same order of magnitude. Planck's length is $1.616255\times10^{-35}$ m (CODATA 2018 value).

Therefore, $R_i = 1.094261\times10^{11}$ m.

The second source for the value of $\Delta x$ is the estimated value of the (curled up) fifth dimension in Kaluza-Klein theory. (As mentioned earlier, the lack of understanding of imaginary numbers led to the requirement of a fifth dimension. However, to reiterate, what Kaluza and Klein assumed to be the fifth dimension actually turns out to be the fourth dimension). They assumed that the fifth dimension takes the form of a circle and the radius of the circular dimension is 23 times the Planck length, which in turn is of the order of $10^{-35}$ m [84].

Therefore, in this case the thickness of the 3D FPHS is given by the diameter of the circular fifth dimension and is thus 2×23 = 46 times the Planck length. It follows that

$R_i = 1.094261\times10^{11}\times(46)^{0.25}$ m = $1.094261\times10^{11}\times2.604290687$ m = $2.84977\times10^{11}$ m.

The average value is given by $R_i = 1.972\times10^{11}$ m. (Averaging two diverse estimates may not be a good idea, but this estimate is only meant to be a rough one.)

The above calculation shows that the universe did not originate from a singularity, but rather from a hypersphere with a radius of $1.972\times10^{8}$ k.m. = $197.2\times10^{6}$ k.m. = 197.2 million kilometres. That is quite large. It is slightly more than the distance from the sun to the Earth (which is 150 million kilometres). At that time, no particles existed in the 3D FPHS, and the 4D hypersphere consisted only of fields bursting with energy. Then something mysterious (and still unexplained) happened.

The universe changed from a static 4D hypersphere to a dynamic 3D hypersurface, and, consequently, the perfect symmetry that existed in nature between the time and space dimensions broke and the flow of time began.

### *3.5 Further discussions*

Many physicists have claimed that the second law of thermodynamics (which states that any spontaneously occurring process always leads to an increase in the entropy of the universe) is the most fundamental law [85, 86]. They fail to realize that this law itself results from the expansion of the universe, because entropy and probability are directly related, and the expansion of the universe leads to an increase in the volume of our 3D space and thus creates more possibilities. In fact, the expansion of the universe gives time its arrow and is thus the most fundamental aspect.

When a balloon expands, its surface area increases. However, the volume (quantity) of the rubber remains constant. Similarly, as the universe expands, the volume of 3D space increases, while the hypervolume of the (hyper) balloon remains the same. This concept explains why entropy increases, whereas the crucial unitarity condition of quantum mechanics (QM) remains intact (giving us the false impression that time is fully reversible at the fundamental level). This characteristic resolves another deep conflict between QM and thermodynamics (classical physics) [87].

It may be prudent to mention that hints of the 4th space (spatial) dimension have been detected by two separate research teams, one in the US and one in Europe[88, 89]. Both of these experiments, utilized a phenomenon known as the quantum Hall effect, and strongly hinted that the true geometry of nature is 4D. This paper claims that it is in this 4D vacuum that the (hyper) balloon universe is embedded. It is this 4D hyperspace into which the universe is expanding.

[A remark without proof (due to lack of space) is made here: Nature's true geometry is revealed and demonstrated by the 'Principle of Least Action (PLA)', from which ALL KNOWN laws of physics can be derived. PLA can be generalized to the 'Principle of Maximum Proper Time', which reduces to a shockingly simple statement: "*The least distance between two points in 4D (hyper) space is a straight line*". The (hyper) balloon universe is embedded in this 4D (hyper) space.]

In an upcoming paper, it will be shown that the Schwarzchild metric is also a dynamic 3D FPHS (moving with a velocity $c$ in the fourth dimension), just like the MST metric. The Flamm paraboloid is an accurate mathematical representation of the Schwarzchild metric (contrary to popular belief) if the dynamic nature is considered. Hence, the rubber sheet model (which is used to teach GR in schools and colleges) should be taken literally rather than as an analogy, provided that its dynamic nature is also assumed. The dynamic nature of the 3D FPHS causes the flow of time (which appears to vary with the strength of the gravity field due to varying slopes of the Flamm paraboloid at different distances from the massive object). A hint of the (opposing) effects of this slope on the spatial stretching scale and gravitational time dilation lies hidden in plain sight in the Schwarzchild metric. The scale factors in the temporal and radial part of the metric are negative inverses of each other. This sort of negative inverse relation is seen in the slopes ($m_1$ and $m_2$) of two perpendicular lines ($m_1 . m_2 = -1$), which suggests the resolution of the slope into cos(θ) and sin(θ) components.

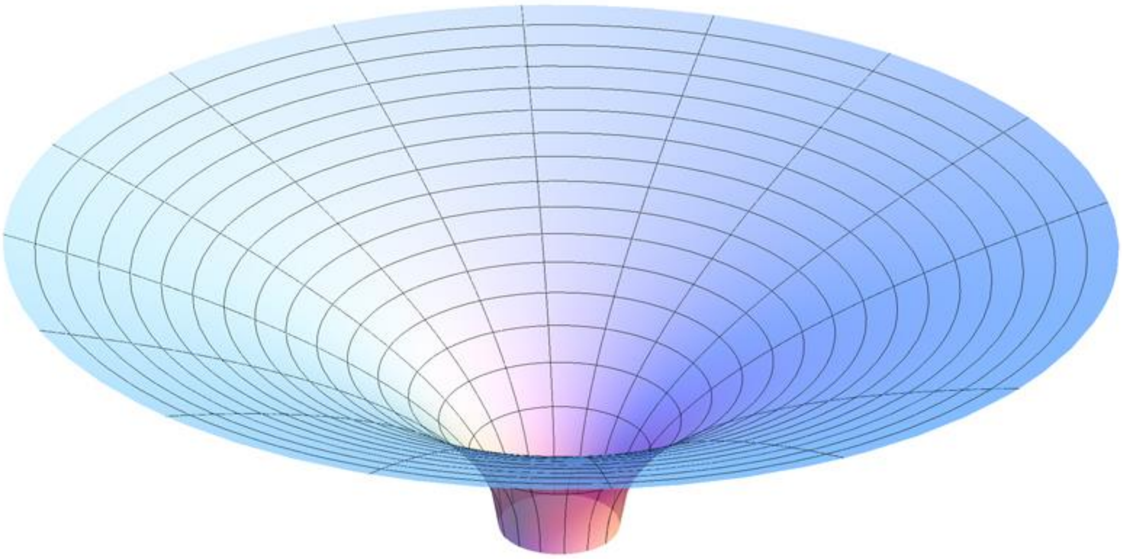
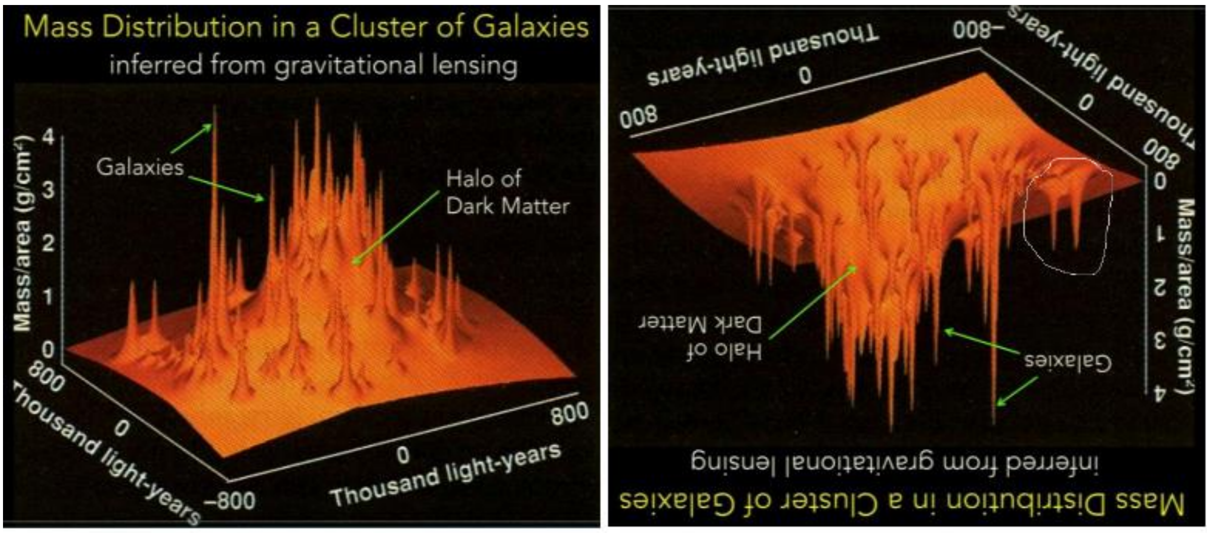


**Figure.4** The spatial curvature of the Schwarzschild solution can be visualized graphically as a Flamm's paraboloid

Picturing gravity as a stretching of 3D FPHS rather than a warping of 4D spacetime provides a key to unlocking the still mysterious aspects of gravity. It magically explains Dark Matter phenomena. **Figure.5** (below) is provided just to stimulate the imagination of the readers.




[**Image source** Galaxy Clusters: Well of darkness; August E. Evrard, **NATURE**, VOL 394, 9 JULY 1998]

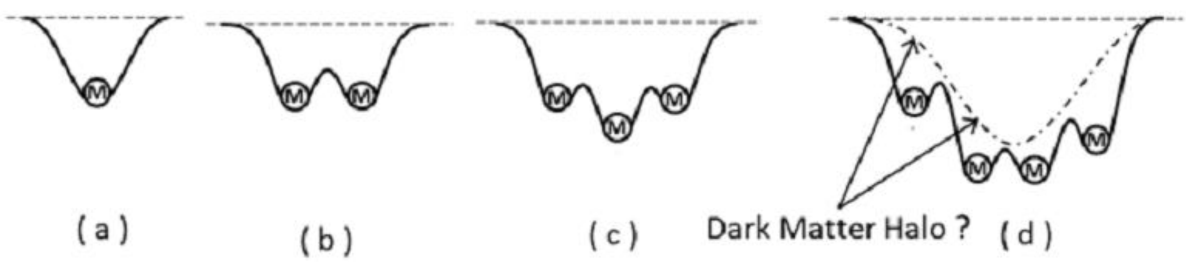


**Figure.5** The rubber membrane model of SpaceTime (which is just the dynamic 3D Field-particle hypersheet model) beautifully explains all Dark Matter phenomena.

***3.6 Is time-travel possible?***

According to special relativity and general relativity, certain suitable geometries of spacetime might allow time travel into the past and future [90]. However the still unsettled question is: are these geometries of spacetime really possible?

Physicists sometimes invoke the possibility of closed timelike curves (i.e world lines that form closed loops in spacetime, which would allow time-travellers to return to their own past). Some solutions to the equations of general relativity describe spacetimes which contain closed timelike curves (example: Gödel spacetime). However it is uncertain whether such spacetime are physically plausible.

Scientific community almost unanimously believe that backward time travel is almost impossible. Any theory allowing time travel would introduce deep paradoxes related to causality (e.g. someone might travel to the past and kill his/her grandfather, and thus prevent his/her own birth in the first place).

General relativity seems to allow certain spacetime geometries such as traversable wormholes, cosmic strings, and Alcubierre drives that might allow time travel. However, arguments from semi-classical gravity suggest that when quantum effects are taken into account into the framework of general relativity, these loopholes may be closed. In particular, Stephen Hawking used semi-classical arguments to formulate the '*chronology protection conjecture*'. His work suggested that the fundamental laws of nature strongly prevent time travel [91]. The laws of physics do not allow the appearance of closed timelike curves.

There exist exact solutions (of the field equations of general relativity) in which world lines intersect themselves (closed time-like curves). Some point in the causal past of the world line is also in its causal future. This situation might be described as a form of time travel. Kurt Gödel first proposed such a solution, which came to be known as the Gödel metric. But his solution requires the universe to have physical characteristics such as rotation and lack of Hubble expansion. The universe does not appear to have to have such physical characteristics.

Wormholes are a special category of hypothetical warped spacetime. Theoretically it is permitted by the Einstein field equations of general relativity [92]. A wormhole can be visualized as a tunnel with two ends at separate points in spacetime (i.e., different points in time, or different locations in space, or both). Wormholes were widely studied as a means of allowing practical time travel.

The first type of wormhole solution discovered was the Schwarzschild wormhole. It would be present in the Schwarzschild metric describing an eternal black hole. Unfortunately, it was found that it would not allow anything to pass from one end to the other, as it would collapse too quickly. Wormholes that allow things to pass from one end to the other (i.e. can be crossed in both directions) is known as traversable wormholes. Further research suggests that it could be possible only if matter with negative energy density (exotic matter) could be used to stabilize them [93].

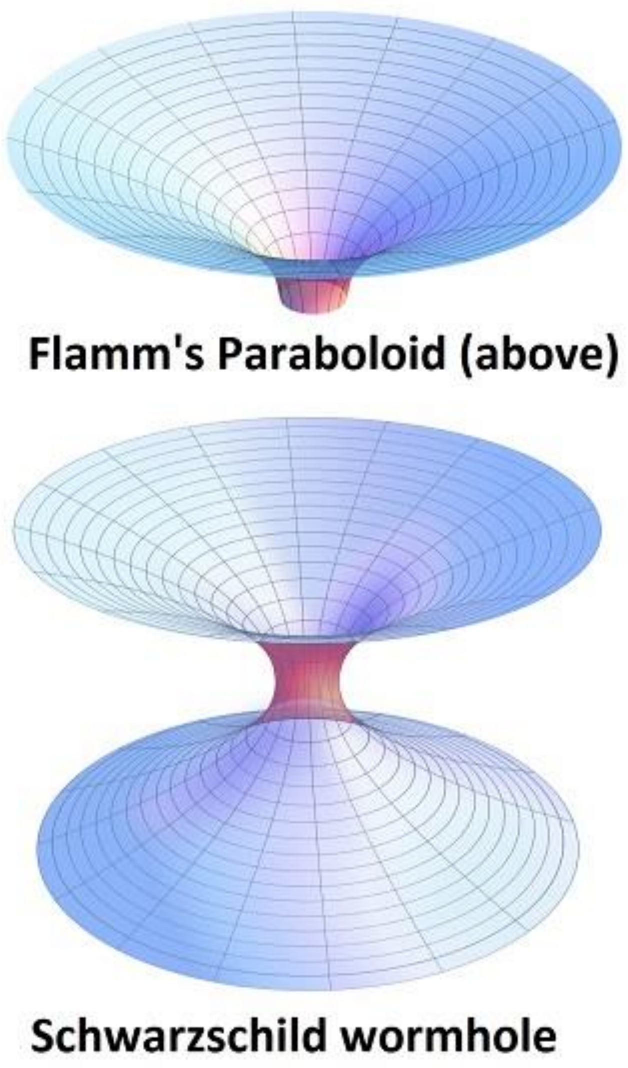



**Figure 6. Is joining together two Flamm's paraboloid to create a Schwarzschild wormhole, physically valid?**

Matt Visser argued (1993), that the two mouths of a wormhole could not be brought in contact without inducing gravitational effects and quantum field that would either cause the two mouths to strongly repel each other, or make the wormhole collapse [94].

Another approach to time travel involves a dense cylinder, spinning extremely fast, which is usually referred to as a Tipler cylinder. This concept/approach is based on a GR solution discovered by Willem Jacob van Stockum [95]. If the cylinder is infinitely long and spins extremely fast about its long axis, then a spacecraft travelling around the cylinder, taking a spiral path could travel back in time (or forward in time, if the direction of its spiral is reversed). However, the speed of rotation and density of the cylinder which must be required is so great that it will be impossible to use ordinary matter which is strong enough to construct it.

A deeper and more fundamental objection to time travel schemes using rotating cylinders (or even using cosmic strings) has been raised by Stephen Hawking. He proved a theorem which shows that according to general relativity it is impossible to build a special type of time machine (i.e. a time machine with the compactly generated Cauchy horizon) in a region where the weak energy condition is satisfied. The weak energy condition means that the region contains no matter with negative energy density (exotic matter).

Some exact solutions in general relativity such as Alcubierre drive (an examples of warp drive) but these solutions requires exotic matter distribution, and generally suffers from semiclassical instability [96]

In short, theoretical routes to the past called time loops have long been hypothesised and studied by physicists. But because they are severely plagued by paradoxes and impracticalities, they have been dismissed as impossible by most physicists.

So why does relativity raises the hope of time travel, only to dash such hopes later?

The answer lies in the fact that we have wrongly interpreted the physical meaning of SpaceTime metrics. As already shown, the MST metric, the FLRW metric as well as the Schwarzchild metric all implies movement of the entire 3D hypersurface along the $4^{th}$ dimension (which gives rise to the flow of time). The presented theory of the SpaceTime and the presented model of the universe brings much clarity to the question of time-travel. But, before proceeding further, it must be reminded that there are two different concepts of time in this theory (which can co-exist peacefully): the absolute universal time and (Einstein's) relative time.

But this leads to a seeming paradox: time is passing at different rates in different inertial frames (as shown by Einstein's relativity), and yet time can't pass at different rates! Nature is adamant to keep everything in the universe of the same age (at any particular instant).

Actually this paradox is more psychological than conceptual. Let us reconsider the twin paradox (without the usual rocket journey).

**The twin paradox (without the rocket journey)**

Let us consider two twins, A and B. The nurse, the midwife and the medical attendant who had witnessed their birth had all certified that the twins were born within minutes of each other.

But somehow twin A started ageing very rapidly (Doctor's said it was a rare case of 'Progeria', also known as Hutchinson-Gilford syndrome). His beard had turned white, his skin wrinkled like raisins, his teeth fell off, and he was already on his deathbed while the twin B barely looked in his 20s.

Now should we say that the twins are of same age, or of different ages?

The answer seems so obvious. Yet we seem so utterly confused, while dealing with this same question that pops up unnoticed in physics. Clearly there are two concepts of time involved here. One is sort of global or universal Time (that is the duration from the twins' birth to this moment). The other is related to the ageing process (it is a sort of process time). All clock rely on some process (radioactive decay, pendulum swing period etc.) Special relativity was so obsessed with light speed travel and time dilation, that it didn't bother what happens even without any rocket travel.

We have grown so utterly confident of the ever increasing accuracy of our clocks that we tend to forget that everything in the universe has a common birth moment-the moment of big bang (which has very strong evidences of have actually happened). Nature is utterly determined to maintain the duration from big bang to this present moment equal for every object in the universe, irrespective of whether it is moving at 99% velocity of light or at rest. Every object in the universe has the same age. (We may say that our own age is 55 years. But if we consider the tiniest constituents of our body, we have to agree with a universal Time). The Hafele-Keating experiment and muon decay experiment has demonstrated beyond doubt that time indeed runs slowly for a fast moving object. But is it the universal Time, or the process time?

We never give a second thought that even the most accurate of our clocks are ultimately based on some **process**, whether it is radioactive decay or atomic transition or whatever. In fact different types of clock would behave differently under varying conditions. For example, an atomic clock would show that time has slowed down in a stronger gravitational field, while the pendulum clock will actually show that time is moving faster. Again consider two exactly identical candles. We can measure time by the rate at which the candles burn. But if we place one candle in an atmosphere with slightly higher oxygen content, it will burn much faster. This shows that the universal Time is much more fundamental, while the process time can vary.

Now coming back to the question of time travel. Any alteration with absolute universal time is impossible. That is because any object (irrespective of its location or velocity of movement) trapped within the surface of the expanding balloon universe will be inevitable dragged along with the surface fields away from the center of the universe. Even in a strong gravity field, although clocks will run slower (which just indicates the process time), the outwards velocity from the true center of the universe for all objects will actually be the same compared to a clock located far away from massive gravitational objects. In the first case, it is the movement of 3D Flamm's paraboloid along the $4^{th}$ spatial dimension (Schwarzchild metric), while in the second case, it is the movement of a 3D hypersurface along the $4^{th}$ spatial dimension (Minkowski metric).

It may be noted that time dilation for fast moving objects will be valid for this presented model of the universe, because Minkowski equations are satisfied by the dynamic 3D hypersurface. But it is the clock time (process time) which shall show dilation. But special relativity (SR) do not allow time travel in the past; it only allows time dilation. That is because, SR also forbids faster than light travel (which would have caused clock time to run backwards!) Gravitational time dilation for clock/process time will hold (in this presented model of the universe) for objects located near massive gravitational objects because the slope of the Flamm paraboloid will split the temporal component into cos and sine components. Hence, the pure time flow will appear as partial time flow (gravitational time dilation) and partial space flow. This space flow is the reason why space near a black hole can be modelled as like a flowing river [97,98].

However, in the quantum world, time-travel is a different story. Let a signal be sent from one location and received at another location. As long as the signal is moving slower than the speed of light (or even at the speed of light), the special theory of relativity shows that all frames of reference can agree that the reception-event happened after the transmission-event. However, when the signal travels faster than light, then, in all reference frames, it is received before it is sent. The signal appears to have moved backward in time!

Quantum-mechanical allows phenomena such as quantum teleportation, or quantum entanglement. It thus allows a mechanism that for faster-than-light (FTL) communication, which appears as time travel. Some interpretations of quantum mechanics such as the Bohm interpretation explicitly require non-locality. Therefore, to maintain correlations between particles, some information is being exchanged between particles instantaneously.

Quantum mechanics allows such time travel phenomena because of exchange of roles of space and time at very small size scales. The key point to note is: particles at the tiniest scales no longer use our familiar 3+1 SpaceTime structure, and hence are no longer bound by the rules of Minkowski SpaceTime. We humans use an imaginary sign with the time dimension. However, very small objects use imaginary sign with the three space dimensions. For very small objects the time dimension becomes a space dimension. That is because, the radius of the balloon universe (which was an impossible direction for us, which forced us to use imaginary numbers) is a real distance when viewed from the centre of the universe. We ignore movement along the radius of the universe (along the 4$^{th}$ dimension). In fact we cannot even feel the movement. In a similar manner, nature ignores movement along the wall of the balloon universe, because all points on it (whether it be the sun or the moon or even the Andromeda galaxy) are all equidistant from the true (big bang) centre of the universe. This interchange of imaginary and real signs create the quantum version of SpaceTime equation:

$$\boldsymbol{ds^2} = (\boldsymbol{c\,dt})^{\,2} + (\boldsymbol{i.dx})^2 + (\boldsymbol{i.dy})^2 + (\boldsymbol{i.dz})^2 = (\boldsymbol{c\,dt})^{\,2} - \boldsymbol{dr^2}\,, \qquad (16)$$

This equation is space-like rather than time-like MST with which we are so familiar with. This above equation creates a super-luminal condition. In fact, all bizarre quantum phenomena arise out of this super-luminal condition. Relativity is inside the light cone phenomena (since nothing can travel faster than light), while Quantum Mechanics is outside the light cone phenomena (allowing instant communications in 'quantum entanglement' experiments).

Very recently, some physicists have shown that in the quantum realm, time travel to the past are possible, and even experimentally feasible [99]. Soon physicists will attempt to send a particle back in time. If successful, it would open the possibility to dispatch messages in the form of quantum signals, back in time.

### *3.7 What happens at the surface? Are there other universes?*

From the presented model of the universe, it is clear that humans are mere trapped beings within the 3D hypersurface of the expanding universe. Therefore, everything we humans have ever observed, and will ever observe happens at the surface. Gravity and electromagnetism can be unified (as Kaluza shown) and both are confined to the (hyper) surface. Gravity do not leak outside the surface. General Relativity has been wrongly interpreted as warping of 4D SpaceTime continuum. Since gravity was assumed to arise from the fabric of Space and Time itself, therefore several previous theories involving higher dimensions took it for granted that gravity must leak into the higher dimensions of space (and hence is weak compared to other forces). However, observations [73] shows that gravitational waves do not "leak" into the extra dimensions, and also gravitational waves propagate in D=3+1 spacetime dimensions, as expected in general relativity. Gravity is also a 3D (hyper) surface phenomena, and arises when the surface is stretched outwards from the centre of the universe by massive objects.

[The following paragraph is just mentioned without proof or further explanation (due to lack of space): The other two forces of nature (weak and strong forces) are also confined within this 3D hypersurface. Even the internal symmetries like U(1), SU(2) and SU(3), which gives rise to all the forces and particles of the Standard Model of particle physics arises naturally from this model as the transition from one viewpoint (3+1) to another viewpoint (1+3) takes place with decreasing size scale, passing through intermediate (2+2) fractal SpaceTime of Relativistic Quantum Mechanics.]

There is no need to put in any matter or energy terms “by hand” in this model (https://wp.towson.edu/5dstm/introduction/ ). However, the fifth dimension (as mentioned in 5D Space-Time-Matter Consortium) is not needed. Only four dimensions are sufficient.

The model of a finite, closed balloon universe in an infinite 4D vacuum (nothingness), naturally raise the question: Are there other universes?

This model cannot deny the existence of other universes. However, it also does not require the presence/necessity of other universes (multiverses). In fact this model, raise question on the necessity of initial inflation before the big bang, and hence may avoid the necessity of multiverse which is inherent in several models of inflation theory.

If other universes were present outside our own, it is highly likely that all are completely isolated from each other. Since gravity do not leak outside the (hyper) surface, they might not even interact gravitationally. Hence, we might never bother about other universes.

**4. Conclusions**

Our universe is in the form of a hyper-balloon expanding at a radial velocity of *c* (the velocity of light). This model overcomes the major challenges faced by the SMC and inherits the successes of the $R_H$ = ct model because it is a constant expansion velocity model of the universe. However, it should be clarified that Melia's $R_h$ = ct model assumes a flat universe, whereas the presented model is of a positively curved and closed universe.

This study may prompt scientists to measure the thickness of the 3D FPHS precisely. However, the limitation is that the fourth dimension is inaccessible to humans, and hence direct measurement of the thickness may not be possible; thus, some assumption must be made.

This study has opened up the possibility of directly measuring the curvature of our universe (using summation of solid angles of a tetrahedron method) to settle the debate of flat versus curved 3D space forever. In the near future, we could send four space instruments (with extremely sensitive equipment), each of them a million miles apart from the other three, to form a tetrahedron in space. Using laser beams, we could measure the sum of four solid angles and compare it with theoretical values for 3D flat space. In addition to directly measuring the size (radius) of the universe from the curvature value, we could also settle the Hubble constant value debate (because we know the value of *c* quite precisely). However, a challenge is that the curvature arising from the outwards stretching of the 3D FPHS due to gravitational effects of the sun, and also the Milky Way galaxy, is far greater than the overall curvature of the universe itself. The curvatures due to the sun and the Milky Way galaxy are both opposite the direction of curvature of the universe (this discussion requires a separate study and hence will not be elaborated here). However, human ingenuity and complicated mathematics might overcome this challenge. It will be better still if someone figures out a clever method of obtaining the sum of solid angles from the CMB spots. One may measure the solid angle at the apex of the cone (formed at the telescope) whose base is the circular CMB spot.

There is an alternate way to prove that the universe has a positive curvature (and hence is necessarily closed and finite), which can be achieved very soon by either the Euclid telescope or the DESI team. The method is as follows:

A circle drawn on curved surface (of a sphere, or a football) has shorter circumference compared to a circle of same radius drawn on a flat surface. For example, a dome-shaped orange peel has a shorter edge than a pancake of the same size. Forcibly trying to flatten it will tear its edges. The equivalent of a circle in 3D is a sphere, and the equivalent of the circle's circumference in 3D is a spherical surface. DESI can see up to 11 billion light years (b.l.y.) away, while Euclid telescope can see upto 10 b.l.y in broad vision mode. A sphere of 10 b.l.y. can be partitioned into spherical bands (say 7-8 b.l.y., 8-9 b.l.y. etc.) The number of galaxies falling in each band can be counted. The predictions of curved, balloon universe differ from the presently accepted 3D flat model of the universe, which predicts the number of galaxies to be proportional to the square of radius. Balloon model predicts the number to deviate (become lesser) from the accepted prediction with increasing radius. This crucial test is based on a hallowed/sacrosanct principle that the distribution of galaxies on a large enough scale of the universe is uniform.

This study has only hinted at the stunning achievements that this model has to offer. Interested readers may wish to consult the preprints [100, 101].

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**Dedication:** This paper is dedicated to my mother (late) Mrs. Basanti Waugh, my father (Shri Lalji Vittal Waugh), and to my "Jathamosai" (uncle), who had seen this day coming through his prophetic vision before he left**.**

**Conflicts of Interest:** The author declares no conflicts of interest.

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# APPENDIX A

[These are excerpts from the book **Fundamental Ideas in Cosmology: Scientific, Philosophical and Sociological Critical Perspectives (Martín López-Corredoira, 2022)**.]

## History and Problems of the Standard Model in Cosmology

Since the beginning of the 20th century, a continuous evolution and perfection of what we today call the standard cosmological model has been produced, although some authors like to distinguish separate periods within this evolution. A possible historical division of the development of cosmology into six periods was proposed by Luminet (2008): (1) the initial period (1917–1927); (2) the period of development (1927–1945); (3) the period of consolidation (1945–1965); (4) the period of acceptance (1965–1980); (5) the period of enlargement (1980–1998), and (6) the period of high-precision experimental cosmology (1998–).

### The Period of Enlargement (1980–1998)

Nonetheless, there were problems that remained to be solved, such as why the Universe appeared to be the same in all directions (isotropic), why the cosmic microwave background radiation was evenly distributed, and why its anisotropies were so small. Why was the Universe flat and the geometry nearly Euclidean? How did the large-scale structure of the cosmos originate? Clearly, work on the fundamental pillars of the cosmological edifice remained to be done. In the 1970s and 1980s, proposals were brought forth to solve these pending problems, with inflation as the leading idea in the solution of cosmological problems at the beginning of the Universe, and the idea of non-baryonic dark matter as a new paradigm that allows the theory to fit the numbers of some observations.

Also, the joining of cosmology and particle physics and scenarios containing baby universes, wormholes, superstrings, and other exotic ideas were born. This excess of theoretical speculation, not based on observations, has led some authors to call this epoch the era of post-modern cosmology (Bonometto, 2001). This union between cosmology and particle physics is due in part to the halting of particle physics experiments because of their escalating cost, a situation that led many particle physicists to move over into cosmology, wishfully contemplating the Universe as the great accelerator in the sky (Disney, 2000; White, 2007). Alas, particle physicists lack the necessary astronomical background—complained Mike Disney—to appreciate how soft an observational, as opposed to experimental science, necessarily has to be. In the 1990s, a third patch was applied to the theory in an effort to solve new inconsistencies with the data in the form of dark energy.

The renovated standard model, including these ad hoc elements, would come to be called the lambda-CDM cosmological model, where lambda stands for dark energy, and CDM stands for cold dark matter, the favoured subgroup of models of non-baryonic dark matter. Some cosmologists referred to it as ‘concordance cosmology’ to emphasize that this model is in agreement with all the known observations. Other authors, critical of the standard model, prefer to call it ‘consensus cosmology,’ wishing to emphasize that this new cosmology is, above all, a sociological question of agreement among powerful scientific teams in order to establish the orthodoxy of a fundamental dogma. This agreement would be mainly between two powerful cosmological groups, the teams dedicated to the analysis of supernovae and the cosmic microwave background, who found a rough coincidence in the necessary amount of dark energy, although with large error bars, that reinforced their belief that they had discovered an absolute truth, thus compelling the rest of the community to accept this truth as a solid standard, while at the same time discarding the results of other less powerful cosmological groups that presented different values of the parameters. Talking about consensus cosmology, Rudolph ('Rudy') Schild (1940–) once queried, "Which consensus? Do you know who consented? A bunch of guys at Princeton who drink too much tea together" ' (Unzicker & Jones, 2013, ch. 3).

**The Period of High-Precision Experimental Cosmology (1998–)**

Rather than major discoveries or proposals, this epoch is characterized by a lack of discussion on the fundamental ideas in cosmology, when it becomes a tenet of belief that all the major problems have been solved. This state of complacency has resulted in excess confidence in the robustness and superiority of the standard model, with little consideration for alternative models. Certainly, some minor topics are being debated, such as the equation of the state of dark energy, and the types of inflation or the coldness or hotness of dark matter, but these are subtleties (Byzantine arguments) within the major fundamental scheme. This is the epoch in which the main enterprise of cosmology consists of spending big money on megaprojects that will achieve accurate measurements of the values of the cosmological parameters and solve any small problems that remain to be explained.

This is also the epoch of the highest social recognition of cosmology: Not only do schools, museums, and popular science journals talk about the Big Bang as well established, to be compared to Darwin's evolution and natural selection theory, but cosmology now occupies a privileged ranking among the most prestigious natural sciences. For instance, cosmology and its four dark knights (CP violation, inflation, non-baryonic dark matter, and dark energy) have been awarded Nobel Prizes in Physics in 2011 and 2019, respectively, for the putative discovery of the dark energy that produces the acceleration of the expansion, and the inclusion of the dark components in our understanding of the Universe. One may wonder whether unconfirmed quasi-metaphysical speculations should properly form part of the body of the recognized knowledge of physics, leaving behind the conservative tradition of Nobel committees not awarding prizes for speculative proposals. Einstein did not receive either of his Nobel Prizes for his discovery of special and general relativity; neither did Curtis for his definitive recognition of the true nature of galaxies in the Great Debate of 1920. Neither Lemaître nor Hubble received the Nobel Prize for their discovery of the expansion of the Universe, but we now have committees that give maximum awards for highly speculative proposals, such as the acceleration of the expansion of the Universe, the reality of which has yet to be confirmed. We certainly do live in a very special time for cosmology.

However, this brand of epistemological optimism has declined with time, and the expression "crisis in cosmology" is stubbornly reverberating in the media. The initial expectation of removing the pending minor problems arising from the increased accuracy of measurements has backfired: the higher the precision with which the standard cosmological model tries to fit the data, the greater the number of tensions that arise, the problems proliferating rather than diminishing. Moreover, there are alternative explanations for most of the observations. At the Anomalies in Modern Astronomy Research online symposium organized by the Society of Scientific Exploration (October 22nd, 2022), Prof. Pavel Kroupa presented anomalies from galactic to Gpc scales (large-scale structures), including some examples of 5 sigma tensions and some mention of Modified Newtonian dynamics (MOND) as an alternative to standard gravity and dark matter. We can complement the range of anomalies in cosmology with further cases of Cosmic Microwave Background Radiation, nucleosynthesis, tests of expansion, CP violation, inflation, and other topics. There is no space in the present text to discuss in detail these topics; the reader interested in these anomalies and tensions can read the recent literature on the collections of problems of the standard model: (Perivolaropoulos & Skara, 2022; Abdalla et al., 2022; Melia, 2022; López-Corredoira, 2017, 2022). CP violation has problems; There is no experimental evidence for a finite lifetime of a proton below $10^{34}$ years (Tanaka et al., 2020).

Inflation has problems; some authors have argued that the inflation necessary to explain a flat Universe is highly improbable (Iljas et al., 2017). Hubble–Lemaître diagrams with type Ia supernovae can be explained without dark energy (López-Corredoira & Calvo-Torel, 2022); also, dark energy can be avoided in other observations.

Doubt is cast upon that precision cosmology derived from Cosmic Microwave Background Radiation analysis, owing to the difficulties in making maps totally free from foreground contamination. Moreover, many alternative explanations of its origin are found in the technical literature, and certain observed anomalies, such as the lack of low multipole signal, alignment of quadrupole and octupole, and others, are at odds with the standard model (Schwarz et al., 2016), which opens the door to possible fundamental errors in the standard cosmological description of this radiation.

In the standard model, it is claimed that helium-4, lithium-7, and other light elements were created in the primordial Universe, and the existence of these elements was used as proof for the necessity of a hot Universe in its first minutes of life. However, only helium-4 has had successful direct confirmation of the predictions, although at the price of requiring a baryon density raises other problems. The observed abundance of lithium-7 is 3 to 4 times lower than predicted (Coc et al., 2012).

Cosmology is not a science like others since it contains more speculative elements than is usual in other branches of physics, with the possible exception of particle physics. The goal of cosmology is also more ambitious than routine theories in physics: cosmology aims to understand everything in our Universe without limit. However, cosmological hypotheses should be very cautiously proposed and even more cautiously received. This scepticism is well-founded. There are scientific, philosophical, and sociological arguments to support this claim (López-Corredoira, 2022).

# APPENDIX B

**Proper representation of negative and imaginary numbers**

Suppose that Mr. XYZ borrowed $1000 from the bank and spent it. Then one can either say that "Mr. XYZ has a debt of $1000" or "Mr. XYZ owns –$1000." However, one must not say that "Mr. XYZ has a debt of –$1000." The negative sign automatically indicates the direction (because debt goes in the opposite direction of ownership). Therefore, if negative numbers are used (i.e., along with the minus sign), then one should use the positive x-axis (i.e., in the same direction as the positive numbers). If one does not use the minus sign, then one should use the negative x-axis (in the opposite direction to the positive x-axis from the selected origin). However, one should never use both together. A similar argument applies to the imaginary number *i* (see **Figure A1** below)

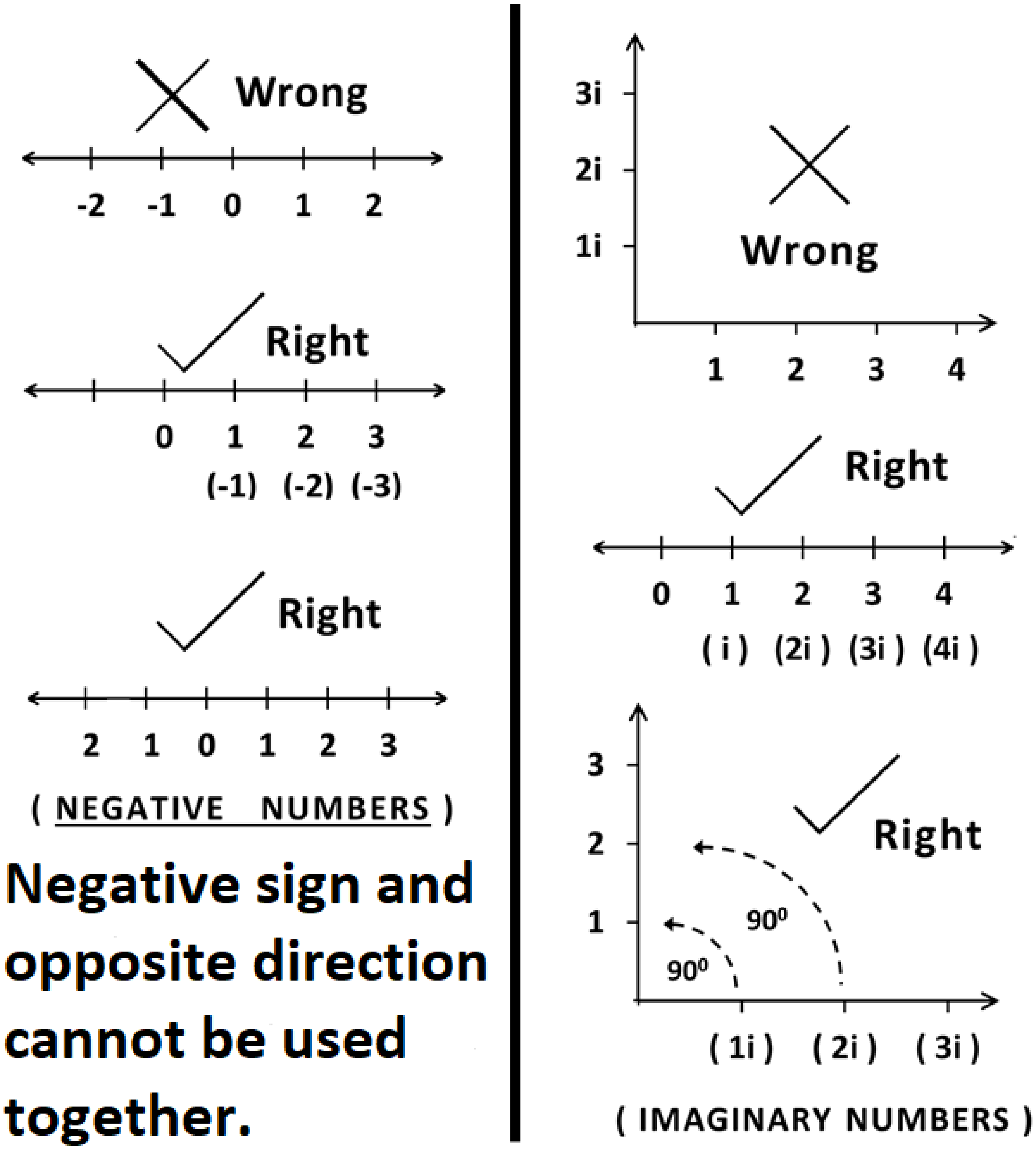


**Figure A1: Correct representations of negative and imaginary numbers**.

*Before proceeding further, two serious issues has to be addressed:*

*If the new representation of the number line concept is adopted, how will it solve the problems of coordinate geometries in mathematics, physics, and other branches of science? Why do we need for such a concept?*

*Regarding the first question, the answer is: One can continue to enjoy all the benefits of coordinate geometries by using x, y and z axes. The only thing which has to be taken care is that one should not use the negative sign on the opposite side of the origin (i.e. negative sign should not be used along the negative x-axis). Similarly, the imaginary sign should not be used if a y-axis is used explicitly.*

*Regarding the second question, the answer is: We urgently need for such a concept. The above mentioned number line concept might seem like a trivial correction to the present globally accepted* *concept. But it changes the physical meaning of SpaceTime metrics entirely. The profoundness of making afore-mentioned corrections becomes evident when one completes reading this manuscript.*

Now returning back to the original topic: It is likely that we make the (above-mentioned) grave but unnoticed mistake because we obsessively want to arrange the numbers (based on their magnitude) on the number line (e.g., the *x*-axis). Suppose that we begin with 2 and compare it to 1. Because 1 is less than 2, we place it to the left of 2. We then compare 1 to 0 and place 0 to the left of 1. Next, we compare 0 and –1, find that –1 is less than 0, and place –1 to the left of 0.

In doing so, we conveniently forget the important fact that we have the origin at 0. On the positive *x*-axis, placing any number to the left brings us closer to origin. However, on the negative *x*-axis, placing it to the left takes it away from the origin. The rule has reversed.

While we were using positive numbers (such as 2, 3, and 12) for ordering, we followed the rule that smaller numbers are closer to the origin and larger numbers are farther away. However, when arranging negative numbers (in the conventional way), we follow the rule that larger numbers are closer to the origin and smaller numbers are farther away.

Therefore, such an arrangement works only if there is no origin on the number line. Such a number line may be of interest to mathematicians (as a fancy ordering tool), but we do not need it for physics. In nature, the origin is definitely at 0 (it is the terminus). Nature does not use negative numbers (or even imaginary numbers). They only occur in our mathematical descriptions of physical laws. Negative/imaginary numbers are only mathematical tools. They do not exist in nature. How can I have –4 cows? (Here –4 is meant quite literally, raising the question, “What does a negative cow look like?”). This situation is exactly why mathematicians were once so reluctant to accept negative and imaginary numbers. They are not physical. In addition, of course we need an origin when working with dimensions. Certainly, we need an intersection (crossing) point between the X- and Y-axes (or even the Z-axis). It is difficult to imagine how a number line without an origin can be used to create a XYZ frame of reference.

The attentive reader will have noted a difficulty. Even using the positive X-axis to arrange negative numbers (as shown in the figure), we still encounter the difficulties that whereas the positive numbers follow the rule that smaller numbers are closer to the origin and larger numbers are farther away, the rule is reversed for the negative numbers. That is exactly why the negative numbers are shown in brackets in the diagram. We cannot order the negative numbers similarly to the positive numbers on the positive *x*-axis. However, this problem disappears completely when we can represent negative numbers as positive numbers in the direction of the negative *x*-axis. In other words, this problem disappears with access to the opposite direction. The above-mentioned problem becomes even more pronounced when we move to imaginary numbers because $i$ = sqrt(–1) is not less than 0, not greater than 0, nor equal to 0. Imaginary numbers cannot even be arranged by comparing their magnitudes (because we lose the property of ordering altogether with imaginary numbers). However, if we have access to another perpendicular axis (in this case, fortunately, the *y*-axis), then $i = 1.i$ represents the (real) number 1 on the *y*-axis. Again the (above-mentioned) problem disappears if we have access to a higher dimension (i.e., perpendicular axis). Therefore, the emphasis is not on where on the *x*-axis the imaginary numbers should be placed (they are just a mathematical convenience anyway), but rather on the fact that they represent a real quantity on a very real axis.

“Why then should we not use an additional axis instead of resorting to imaginary numbers?” This is certainly a good question. If the *x*-axis is not sufficient, then we can add the *y*-axis. If we need another dimension, we can use the *z*-axis. Then we are stuck. We cannot go any farther. However, the shocking reality is that we frequently need another dimension that we do not have access to. We are flatlanders (see **Figure A2** below). The need for a fourth dimension was recognized by Einstein and Minkowski (although they missed the actual picture and created problem with a block universe view).

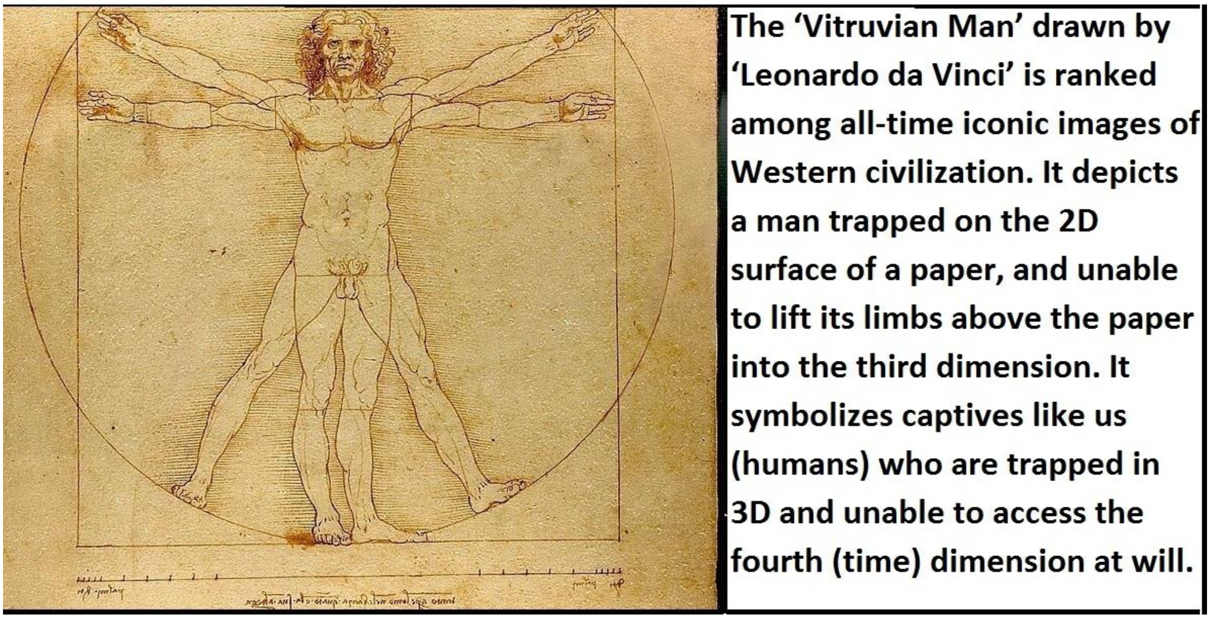


**Figure A2**. Humans are 'flatlanders', trapped in a 3D hypersurface, when looked from the fourth dimension.