Static Time, a Localized Universe, and a Cosmological Uncertainty Rule

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Abstract. This paper offers a solution to the problem of time by proposing that if the universe is time-like, stationary, and bounded, it can be divided into static temporal gradations or contours. This led to the establishment of an energy diffusion flux (EDF) equation from which the Planck and Hubble times were derived. It was found that time becomes unimportant after applying Gauss's Law on EDF when searching for the characteristic length of the Universe ℵ. Additionally, an uncertainty rule that may limit our simultaneous knowledge about the scope of space and the masses it contains was discovered. The paper concludes that if the universe is stationary and bounded, then it did not have a beginning compared to a vast, probably timeless background. Its appearance of having a beginning is because the information is largely conveyed through optics.

Keywords: Static time, the problem of time, Planck time, Hubble time, cosmological uncertainty rule, information limit.

1 Introduction

The issue of time presents itself in the form of two conflicting perspectives within the domain of physics, specifically between the theories of general relativity and quantum mechanics. General relativity conceives of time as a relative and mutable entity, whereas quantum mechanics regards it as absolute and unchanging [1]. These raise questions about its ontology in the philosophy of physics. One wonders why it appears to move only in one direction, despite not being dictated by any known physical laws at the microscopic level. While in classical systems, entropy takes a parallel trajectory as time [2]. The issue brings to light an ontic inquiry in the physical realm and its authenticity as a tangible, separate occurrence. Additionally, it explores the interrelated question of why time is perceived to progress unidirectionally despite the lack of established physical laws mandating a single direction at the microscale.

The Borde, Guth, and Vilenkin theorem, commonly referred to as the BGV theorem, was first established in 2001 and refined in 2003. This theorem posits that any spacetime undergoing sufficient inflation or expansion must exhibit incompleteness in both the null and negative time-like directions [3]. This study regards the theorem as a fundamental aspect. It endeavors to examine the relationship between time and the Universe, with a particular emphasis on the hypothesis that it is a synthetic consequence of the modulation of consciousness through optics. The study takes as its starting point the concept that the Universe possesses an internal sense of time while maintaining an external staticity, as posited by Page and Wooters in 1983

[4]. Given the limitations inherent in our access to information, one of the objectives of this inquiry is to show that the perception of time is primarily an epistemological problem, rather than a fundamental feature of the physical universe. The age of the Universe is primarily determined through the influence of light on our perception of the progression of information. This highlights the crucial role that optics plays in shaping our understanding of time.

This inquiry endeavors to investigate the minimum conceivable interval of time and the highest potential age of the universe while using various in-house terms such as "isotemporal gradations," "time wrinkles," and "static temporal contours." The research is founded on two key premises: (1) the existence of time within the universe and (2) the static nature of time when considered from an external viewpoint. This viewpoint is grounded in energy diffusion and the geometrical implications of the hypothesis, as demonstrated by the works of Moreva et al. [5]. The Universe here is treated as having an internal time while being externally static [4]. This research is based on the premise that the diffusion of energy occurs from a temporal perspective and that the proposed hypothesis will demonstrate the atemporal geometry it leads to.

2 Methods

2.1 The Universe is a Distinct Time-like Point Amid a Vast Timeless Environs

This chapter aims to propose a simplified explanation of the problem of time. To this end, the study accepts a virtual "beginning" of the Universe (U hereafter). This virtual beginning is represented by a spatial point ($\Delta r \rightarrow 0$) as per the BGV Theorem [3] and is situated at the initial time t_0, as illustrated in Figure 1 below. The spacetime interval is described by Equation 1

$$\Delta s^2 = c \cdot \Delta t^2 - \Delta r^2 \qquad (1)$$

The spacetime quantity Δs is at its smallest at t_0. If $\Delta r \rightarrow 0$ and $c \cdot \Delta t > 0$, then $\Delta s > 0$, thus, Equation 1 describes a time-like point Universe (U hereon) and can be further simplified to

$$\Delta s^2 = c \cdot \Delta t^2 \qquad (2)$$

This study endeavors to establish the essentiality of the theorem proposed by Page and Wooters [4]. Their equation of motion, which will not be used here, expresses a time evolution of a system in terms of its stationary states, which are determined by a set of observables that commute with the system's Hamiltonian (if it exists). Their approach provides a way of understanding the dynamics of quantum mechanical systems without relying on a time-dependent Hamiltonian. This study meanwhile will try to accept such an approach and posit U as a closed, static system, and characterized by a time-like dimension [3]. The inception of U is denoted by a point with an initial radius of $r_i \rightarrow 0$, expressed in Equation 2, highlighting the uniqueness and limitation of U relative to its extensive background (hereon referred to as TEO). The assumption that the Universe began as a point (i.e., $\Delta r \rightarrow 0$) necessitates the characterization of U as a closed and distinct system, as the absence of a clear demarcation between U and TEO would result in mathematical complexities. The whole geometry of such a point as a closed system can be described by Equation 3, which denotes its time-like diameter

$$\Delta s_{tot} = c \cdot \Delta t_{tot} \tag{3}$$

The concept of a Timeless External Observer (TEO) around U is predicated on the latter's internal time-likeness described by Equation 2 and the fact that $r_i \rightarrow 0$. This TEO must be fundamentally distinct from U, which is a finite system with boundaries. For TEO to be external to U in a strict sense, it must possess an expressively greater radius, thus, rendering U to be minuscule. As such, the radius Δr of U is virtually point-like compared to TEO and conservative of its time-like nature.

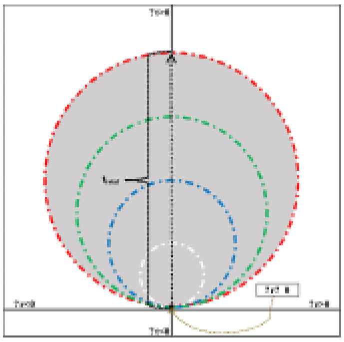

Fig. 1. This figure shows the Universe as a holistic spherical spacetime at age t_{total} when compared to TEO. And compared to the vastness of the surrounding non-spacetime environs, it appears to be a time-like static sphere in multi-layered iso-temporal curves.

For an internal observer (IO) who is fixed at a position along the time-like axis from $\Delta t = 0$ to t_{total}, as the Universe (U) "inflates" from a point to its maximum size, her trajectory would follow the timeline's outward direction as suggested in Figure 1. Every surface of the sphere for each point along the time-like axis should belong to a single static equitemporal curve Δt (which this study quips as time wrinkles). If the Block Universe is correct, then the whole spacetime should be static or in a stationary state, finite, and bounded from a reference frame outside of the Universe. If we humans could designate gradations on a solid cube, we could also do the same for a presumed finite and stationary Universe; albeit not literally.

Given the theoretical framework established by Einstein, Page and Wooters, and Borde, Guth, and Vilenkin regarding the maximum speed limit of light in the Universe [6,7], the static nature of time [4], and the Universe is not along the negative time-like direction [3], respectively, this inquiry suggests that

"If the Universe is static, time-like, and finite then, it could be divided into invariant gradations proportional to an intrinsic internal speed."

This shall henceforth be referred to as the Invariant Time Postulate (ITP), alluding to the Block Universe perspective. Another way to describe this postulate is that if spacetime ds could be divided equally by time dt, the result should be the speed of light c but if and only if time dt was static or invariant. ITP proposes that the total sum of the static gradations along the time-like direction is referred to here as the age of the Universe. Later this study will explain why time must only be internal within a closed system and does not extend beyond the limits of the said system. The postulate could also be interpreted to mean that dividing the stationary and finite Universe ds at intervals dt will yield a constant of proportionality equal to the speed of light c.

The maximum internal speed determines how observers within the system perceive information. Furthermore, the placement of universal materials such as electrons and galaxies in each temporal segment is distinct from preceding gradations. The resulting disparity between segments generates contrasts and, thereby, the perception of time and progression. The proper time or age of the Universe is comprised of a series of static equitemporal gradations (or contours) that, from the viewpoint of an external observer, appear like what is described by Page and Wooters [4]: unchanging, static, or invariant. Thus, an external observer would concur that the Universe is finite and exhibits an internal age but is only stationary.

In contrast, time appears to flow for all subluminal internal observers. However, at the zenith of the Universe, when it reaches its maximum temporal gradation, time ultimately ceases, coming to a halt against the spaceless and timeless environs. Externally, spacetime could be assigned with gradations and can be divided into segments of isometric lines or curves. Each segment represents a unique set of spatiotemporal configurations relative to other segments. However, if the concept of static time is valid, the entire length of the timeline must be unchanging and appear completed and process-free. And as a result, the cumulative measurement of spacetime gradations is invariant and encapsulates the holistic spatiotemporal history of the Universe.

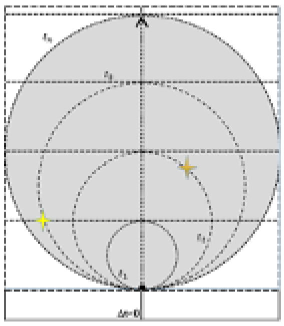

Fig. 2. Relative to an external observer, the Universe contains static equitemporal contours (isometric lines) – setting boundaries between each segment that contains unique configurations in spacetime. Each static isocurve (contour) is globally equitemporal. The Universe U has a proper time, assuming ITP to be true.

For TEO, the contrasting stages do not flow but are rather understood as a series of isometric boundaries (or contours) designated out of the static spacetime geometry. Since each contour lies 90° from the time-like axis, assuming ITP to be true, then, the universal coordinate time Δt (the timeline) must also be the proper time Δτ (see Fig. 1 or 3). ITP could be inferred from either Equation 2 or Equation 3 with the speed of light setting the rhythm for each succeeding temporal curve and, thus, should create isometric line boundaries rated as

$$\frac{\Delta s}{c} = \Delta t \tag{4}$$

Notice that time is limited by the speed of light. Equation 4 implies that dividing the whole spacetime Δs by c is the limiter and if that results in a series of intervals, then, isometric contours of time should set the boundaries for each succeeding indices of the Universe. That is, one interval equals one space-like gradation equals one current Universe, and so on (see Figure 3). If each segment of a time-like Universe has a proper timeline (Equation 4), then, it is finite or the designated timeline is rendered invariant. If ITP is true, then, the implication is that Δs could be divided now from Equation 3 with either Δτ (proper age) or Δt (time interval) and the result would always be c:

$$\frac{\Delta s}{\Delta t} = c \tag{5}$$

Equation 5 suggests that internal observers will concur on the constant speed of light within spacetime. It further implies that the length of each segment, relative to TEO, is cumulative of the overall spacetime geometry. Another perspective, as depicted by Equation 6, is that the ratio of the spacetime interval Δs of the Universe over its proper time Δτ is equal to the speed of light c, thereby characterizing ITP as

$$\Delta s \cdot \sum_i \cdot \ \Delta\tau_i^{-1} = \sum_i s_i \cdot t_i^{-1} = c \tag{6}$$

Setting Δr→0 and c·Δt > 0 (i.e., Δs is time-like) describes a time-like geometry. The idea of time is true for all internal observers whose information sensing and consciousness are largely dependent on electromagnetic waves of which light is part of the spectrum. The term Δr→0 should be true if and only if the size of the Universe is insignificant enough as compared to its external environs. If Δs > 0, then it implies that the Universe is time-like. Given ITP, Equation 5 could also be expressed as

$$\left(\frac{\Delta s}{\Delta t}\right)^2 = c^2 \tag{7}$$

Since this study deals with a time-like Universe (i.e., BGV theorem) with infinitesimal time dt being invariant (i.e., if ITP is true), Equation 7 should evolve into

$$\frac{ds^2}{dt} = c^2 dt \tag{8}$$

(Note that Δs^2 is somewhat the ambiguous shorthand for $(\Delta s)^2$ but will be used in this way throughout this paper.)

2.2 Energy-Diffusion Within a Static Universe

If ITP is true, then we could say that Eq. 8 has a unit similar to thermal diffusivity, which measures the rate of heat transfer of a material from its hotter to cooler segments. Also related is kinematic viscosity, which is defined as the ratio of a fluid's viscosity against its density. Thermal diffusivity is the conductivity of a material divided by its density and its specific heat capacity given a constant pressure. Also related are the velocity potential and stream function in meteorology. The said quantities have an SI-derived unit of $m^2 \cdot s^{-1}$. If spacetime has a similar pervading diffusive energy ε, then, it could be possible that if we divide the minute intervals of this quantity (dε) by the minute changes of spacetime ds, then, the result should simply describe ITP (i.e., Eq. 9) similar to Eq. 5 or 8:

$$\frac{ds}{dt} = \frac{d\varepsilon}{ds} = c \qquad (9)$$

where the constant of proportionality is the speed of light c if and only if ITP is true. The quantity designated as dε has a unit of $m^2 \cdot s^{-1}$, which is equivalent to the units used for thermal diffusivity (κ), kinematic viscosity (ν), velocity potential (χ), or stream function (ψ). If Equation 9 is true, the rate of change of the energy diffusion (dε) with respect to (wrt) the spacetime interval (ds) is equal to the speed of light (c). This implies that dε represents the diffusion of energy over the spacetime interval ds. Equations 8 and 9 can provide an expression for thermal heat capacity, where the speed of light squared now shows to be the specific heat capacity of the Universe:

$$\frac{d\varepsilon}{ds} \cdot \frac{ds}{dt} = c^2 \qquad (10)$$

And Equation 10 should further reduce to

$$d\varepsilon = c^2 \cdot dt \qquad (11)$$

Equations 10 and 11 may suggest a relationship with the mass-energy equation, as first proposed by Einstein [6]. This relationship can be explored by taking the ratio of the change in energy (ΔE) to the equivalent change in rest mass (Δm) as

$$c^2 = \frac{\Delta E}{\Delta m} \qquad (12)$$

Equation 11 or 12 suggests that the speed of light (c) is proportional to the acceleration of energy diffusion within the time-like universe, provided that time is invariant (ITP). This implies that the value of c^2 could also be interpreted as the acceleration of energy diffusion or, more succinctly, as the thermal heat capacity of the universe and should be by itself intrinsic and, thus, invariant. If these are all valid, this inquiry suggests that

"The intrinsic thermal heat capacity of the Universe is equal to the square of the speed of light if and only if its total internal energy is proportional to its entire rest mass."

Or that the Universe can be thought of as an accelerated energy-diffused space equal to the speed of light squared if its total internal energy is proportional to its entire rest mass. This is the dynamic time postulate (or DTP hereafter).

3 Results

3.1 A Cosmological Uncertainty Principle

Following DTP and Equation 12, energy ΔE, given a rest mass Δm, can be expressed as proportional to the rate of change of energy diffusion dε wrt the proper time dt. To generalize Equation 11, it should be assumed that this study has not settled yet on the value of the proper time but that it is integrable. Integrating for dε and dt, then, an energy diffusion interval Δε within an invariant isometric curve Δt appears as

$$\Delta\varepsilon = c^2 \cdot \Delta t \tag{13}$$

Combining Equation12 and 13, assuming DTP as valid, gives

$$\Delta\varepsilon \cdot \Delta m = \Delta E \cdot \Delta t \tag{14}$$

Since this inquiry deals with dr→0, or likewise, a quantum mechanical system, the right-hand side of Equation 14 could be the Energy Uncertainty Equation [8,9] and it should simplify to

$$\Delta\varepsilon \cdot \Delta m = \frac{h}{4\pi} \tag{15}$$

Should Equation 15 be called the Cosmological Uncertainty in Energy Diffusion (or, the Cosmological Uncertainty hereon)? And should, at the very least, reduce as Equation 16:

$$\Delta\varepsilon \cdot \Delta m = \frac{\hbar}{2} \tag{16}$$

where $\hbar$ is the simplified Planck constant.

Equation 16 seems to agree with the BGV theorem (2003), which suggests that the Universe's expansion rate never gets below some nonzero value, no matter how small. This uncertainty equation could suggest that the greater the scope of energy diffusion in spacetime we know, the less certain we are of the masses that it comprises. Or, the more certain we are of an astrophysical mass, the less certain we are about its spatiotemporal history. Could Equation 16 describe why it is hard to determine the dark matter or dark energy every time we observe a distant galaxy?

3.2 Gauss' Law on Energy Diffusion Flux

If ITP is true, then the Universe is a closed system, finite, and static. This can help us treat its energy diffusion to be a measure of the rate of energy transfer from its hot region (i.e., at the beginning) to its cold end. This diffusive energy could be treated as a kind of heat flux and should be treated as a vector quantity extending from its starting point (i.e., $\Delta r \to 0$). And from there, assuming Page and Wooters [4] are correct, then, we can subject the fluxes under an enclosing area to estimate the average. If the energy diffusion field ε is at right angles to a spatial element dA, then the former should be directed at each point of spacetime. Energy diffusion flux is a surface integral of time dt over a closed surface dA, analogous to how gravitational flux is a surface integral of a gravitational field and should have its own Gauss's law.

As the initial rest mass is transformed into energy, heat diffusion is also created. Hence, we could solve for the total age of the Universe, assuming $\Delta s^2 > 0$. To do this, we have to hold the Universe to be time-like or assume the BGV theorem. We also need to test how its diffusion flux appears or assume internal processes to be dynamic by applying Gauss's Law on fluxes [10]. Since the starting geometry is a point or $\Delta r^2 \to 0$, a sphere is a probable progression for the Universe's advanced structure given the shape's preponderance amongst stellar bodies. Later, even without this assumption, we can still deduce that the whole Universe must be spherical (see Equations 38 and 41).

Let us assume a spherical area that perfectly describes this point with a radial element dℵ. Equation17 describes the diffusing energy fluxes through that spherical area dA as

$$\Delta\varphi = \oiint_{\partial V} \varepsilon \cdot dA \tag{17}$$

where the lower boundary ∂V is any closed surface (the boundary of an arbitrary volume V); dA has vector **A**, whose magnitude is the area of an infinitesimal piece of the surface ∂V and whose direction is the outward-pointing surface normal. Quantity **ε** is the energy diffusion flux vector directed away from the singularity and never goes back in time. That is, the solution for the energy diffusion flux Δφ for a closed sphere with radius dℵ should be

$$\Delta\varphi = 4\pi c^2 \aleph^2 \Delta t \tag{18}$$

where c^2 is the speed of light squared and ℵ is the average radius of the Universe at time t (or the total time enclosed within the surface ∂V). (NB: a closed integration was performed for Equation 17 with an assumption that it can be integrated from 0 to ℵ.) Hence, Gauss's Law on Energy Diffusion Fluxes (or EFD hereon) states that: "Energy diffusion fluxes flow in one direction within the Universe from its singularity towards its maximal boundary and are proportionate to the system's total internal time and characteristic radius."

Similarly, if the distance from the point source is not important, we could interpret the energy diffusion flux Δφ that is normal and passing through an area A as

$$\Delta\varphi = \Delta\varepsilon \cdot A = \Delta\varepsilon \cdot L^2 \tag{19}$$

where area A is agnostic about the distance of the source point. If ITP and the idea that the Universe is finite and static are true, coupled with the Gaussian Law on Diffusion Flux (EFD), Equation 13 will imply then that Δε has a uniform energy diffusion throughout Δs. If ITP and EFD are true, we then can claim that a quantity Z describes the rate of change of energy diffusion flux dφ wrt time dt:

$$\frac{d\varphi}{dt} = Z \tag{20}$$

Generalizing and integrating Equation 20 will give us

$$d\varphi = Z \cdot dt \tag{21}$$

Combining Equation18 and 21, we will arrive at Δt

$$\Delta t = \frac{\Delta\varepsilon}{Z} \cdot \left(4\pi\aleph^2\right) \tag{22}$$

By the way, the Energy Uncertainty (Equation16) for Δt is at least

$$\Delta t = \frac{\hbar}{2\Delta E} \tag{23}$$

Equation 23 is important for postulate DTP in that it shows that time started to make sense (from a Presentist's perspective) once an energy ΔE was created within a very short time interval Δt and was accelerated at a diffusion rate of Δε (see Equation 15 or 16 for such a connection). If this energy started off the Big Bang, the time it took for that to be possible is virtually and extremely minute. Since energy diffusion is strictly internal, time must be part of an internal system.

To find an expression for the radius of the Universe whose origin is where the Big Bang energy ΔE took off, we need to combine Equation 22 and Equation 13. Incidentally, Equation 13 can be used to solve for the mean energy diffusion flux of the entire Universe U. The radial length of the Universe ℵ is, thus,

$$\aleph = \frac{1}{2c} \cdot \sqrt{\frac{Z}{\pi}} \tag{24}$$

where $\aleph \geq \ell_P$. Aleph length can stand for the smallest or the largest radius of the Universe depending on the nature of Z. Note that time drops out of the calculation when we try to look for this length and since Z could be shown to be not ultimately dependent on Δt. Equation 24 supports our case for a timeless external backdrop (i.e., TEO the Background) where time is nonexistent (since the term cancels out for all lengths of U). Anything external of U, time ceases to exist or becomes unessential. In the next chapter, Z will be further explored to solve for a possible value of ℵ.

3.3 **What May Z Stand For?**

Z, from Equation 20, can stand for the rate of change of energy diffusion flux wrt to a proper time. Z can be called the diffusion flux factor. To determine what Z is, suppose an energy ΔE is created at a very short time Δt at the hottest portion of the Universe and, thus, locates the energy diffusion acceleration point (assume DTP) that passes through a characteristic area A. To solve for the value of Z at this virtual time Δt, the energy diffusion flux Δε (see Equation 13) passes through spacetime area A and should have an expression of

$$\Delta\varphi = \Delta\varepsilon \cdot A \tag{25}$$

So, combining Equations 25 and 21 will yield

$$Z \cdot \Delta t = \Delta\varepsilon \cdot A \tag{26}$$

From DTP, the ratio of Δε/Δt is c^2 – the speed of light squared – and, therefore, Equation 26 could be further reduced to

$$Z = c^2 \cdot A \tag{27}$$

The minimum possible value of ℵ, from Equation 24, if A is equal to the Planck Area $(\ell_P)^2$, would be $0.3\ell_P$. Now, since ℓ_P is the smallest length scale and anything below it means that no current experimentally corroborated models of physics can make meaningful statements, then, $0.3\ell_P$ has no physical meaning That is, a $0.3\ell_P$-singularity would not make any sense or singularities should at least be ℓ_P. Note that dr→0 means that the Universe is time-like (see [3]). It can also be said that if A in Equation 27 is the Planck Area, then Z has the smallest possible measure of

$$Z = c^2 \cdot l^2 \tag{28}$$

3.4 A Connection to the Bekenstein Limit?

Could Z have a possible connection to Information? It is known that the Bekenstein-Hawking Entropy for a blackhole SBH (see Bekenstein 1981) as reported by Freiberger [11] is given as

$$S_{BH} = \frac{1}{4} \cdot \frac{A_+}{l_P^2} \tag{29}$$

where the horizon area A+ will increase if new masses Δm are added by

$$A_+ \geq \frac{1}{4} \cdot \frac{8\pi \cdot GR \cdot \Delta m}{c^2} \tag{30}$$

(where R is the radius of a sphere that can enclose a black-hole system given EFD). Does adding more uncertainty in the mass Δm, make A_+ more certain? Combining Equations 29 and 30 will make Z appear as a denominator if A in Equation 27 happens to be the Planck Area (i.e., either a triangle or a square, see Equation 28):

$$S_{BH} \leq \frac{2\pi \cdot GR \cdot \Delta m}{Z} \tag{31}$$

And, thus, from Equation 31, the maximum value of Z would be

$$Z = \frac{2\pi \cdot GR \cdot \Delta m}{S_{BH}} \tag{32}$$

If the Bekenstein-Hawking entropy SBH is equal to the Shannon Information Entropy

$$S_{BH} = I \cdot k_B \cdot \ln 2 \tag{33}$$

(where I stands for information and kB is the Boltzmann constant), then, in terms of information limit I, combining Equation 32 and 33 will result to

$$I \leq \frac{2\pi \cdot GR \cdot \Delta m}{Z \cdot k_B \cdot \ln 2} \tag{34}$$

Is it possible that Z (the energy diffusion flux rate of change) in Equation 34 is connected to Information and Entropy physics? If U has a constant energy diffusion acceleration rated at c^2 in Z given a constant 2D area A of equal length ℓ_P, then, the maximum Bekenstein information load for the Universe – assuming the Z-Hubble area and using Equation 34 – is about 20 trillion gigabytes. Equally, with Z-Planck pixels with side ℓ_P as aggregates of the Universe, the maximum information load would be about 1.0×10^{145} bits (or 1.3×10^{135} GB).

3.5 **A Spherical Time-like Universe?**

Given that energy diffusion (ε) shares similar dimensions with the rate of change of spatial area over time (i.e., L^2T^{-1}), it may be considered that dA/dt = ε. Based on this, if both the Invariant Time Postulate (ITP), which states that time is invariant for an external observer, and the Diffused Time Postulate (DTP), which posits that the universe is an accelerated energy-diffused spacetime for internal observers, are valid, then it follows that

$$\frac{dA}{dt} = c^2 \cdot t \tag{35}$$

To get a sense of the energy diffusion on a particular segment of the Universe, a very thin slice of the surface area through which the energy diffusion flux (EFD) acts should be compared against time (the local gradation of that area). And the thermal diffusion in that area should be proportional to a Cosmological Specific Heat Capacity (CSHC). For now, this study assumes that CSHC is proportional to the total amount of energy of the Universe divided by its total rest mass, a constant. And combining this specific heat capacity with a known value of time of that surface will give us a sense of energy diffusion through that area. This is the rationale for Equation 35. If this equation is multiplied by dt on both sides and integrated with their respective lower and upper bounds (from 0 to A_{total} for dA and from 0 to t_{total} for dt) will lead to

$$A_{tot} = \frac{1}{2} c^2 \cdot t_{tot}^2 \tag{36}$$

Equation 36 represents the total area of a mature universe from its inception to its ultimate endpoint, assuming the finitude of the universe as suggested by ITP. To determine this total area, two light cones will be used as depicted in Figure 4A and will be referred to here as the Universal Light Cones. The light cones serve as an effective means of inferring the overall area over which light has propagated throughout the history of the universe and offer a straightforward approach. The absolute past and future light cones possess equivalent two-dimensional circular areas, and when combined, they form the structure shown in Figure 4B.

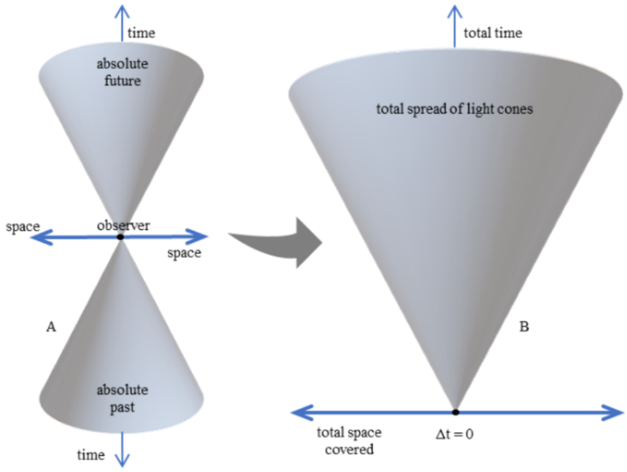

Fig. 4. (A) The Universal Light Cones (i.e., the two nappes being equal) are the path that a flash of light, emanating from a single event (i.e., the Big Bang singularity at the center), travels in all directions. (B) The total light spread from beginning to end – covering the entire history of the Universe.

The equation below describes this entire area:

$$A_{tot} = \pi R^2_{past} + \pi R^2_{future} = 2\pi \cdot R^2_C \quad (37)$$

where $A_{past} = A_{future}$. Meanwhile, A_{tot} is the full area upon which the Universe's total energy diffusion flux ε has passed. The acceleration of energy diffusion fluxes should have followed the trajectory of light as it moved through spacetime, given Equations 5 and 9 and postulate DTP. To solve for total time t_{total}, the cue from Equation 36 and Equation 37 will be taken by equating them together – taking R_C to be the radii of the cones. This scheme should result in

$$c \cdot t^2_{tot} = 4\pi \cdot R^2_C \quad (38)$$

Equation 38 tells that squaring c and multiplying it by the square of the total time of the Universe describes a spherical surface area. That means that the shape of the Universe is spherical while the total time (maximum age of the Universe) should be

$$t_{tot} = \frac{2R_C}{c} \cdot \sqrt{\pi} \quad (39)$$

R_C should come from Equation 24, which describes the radius of a spherical Universe. As a side note, the square root of π could be the area under the curve of the Gaussian function. If R_C is substituted to ℵ in Equation 24, then, the total time in Equation 39 for light to move from the origin to the edge of the spherical Universe is

$$t_{tot} = \frac{\sqrt{Z}}{c^2} \tag{40}$$

It can be seen in Equation 24 that time is missing outside of spacetime. From the same equation, it can be deduced that the smallest possible radius for the Universe should not be less than the Planck Length. If ITP and DTP are both valid, time should be dynamic for any internal observer yet invariant for an external one. From the right-hand side (RHS) of Equation 38, U's total time is described by a spherical geometry – a spherical 4D cosmos – that grows from a singularity (absolute past) to its maximum size (absolute future). A time-like static expression (i.e., combining Equations 2 and 38) can be derived for a spherical Universe with a radius R_C:

$$\Delta s^2 = 4\pi \cdot R_C^2 \tag{41}$$

Equation 41 infers that the total surface area of a 4D spherical Universe is as a time-like spacetime interval given the left-hand-side (LHS) is related to the $c^2 \cdot t$ term. Likewise, it shows that if static time is true (assuming ITP or see [3]), a spherical Universe (Equation 38) emerges. This shows that the Universe could also act as a localized body amid a timeless environment. And Equation 40 will be suitable if values of Planck and Hubble times should be sought. The total time within a Planck Area that experiences a Z-energy flux can be solved by combining the smallest possible Z (see Equation 28) with Equation 40. The result would be

$$t_P = \frac{l_P}{c} \tag{42}$$

If you noticed, Equation 42 is the exact expression for **Planck Time**. Figure 5 shows that Z can describe a 2D plane where the rates of change of diffusion flux wrt time occur. The Planck Area (see Fig. 6) could be the smallest polygon in the Universe since anything smaller would mean physically undefined. Doing the same procedure using Equation 27 for the Hubble Length will give us

$$Z = c^2 \cdot L_H^2 \tag{43}$$

Equations 43 and 40 will eventually lead us to the expression for the total age of the Universe:

$$t_H = \frac{1}{H_0} \tag{44}$$

Equation 44 is the expression for **Hubble Time**. The reader is invited to check the process to know how this study arrives at Equations 42 and 44. The Z-energy flux functions (Equations 28 and 43) are deemed important in the derivations.

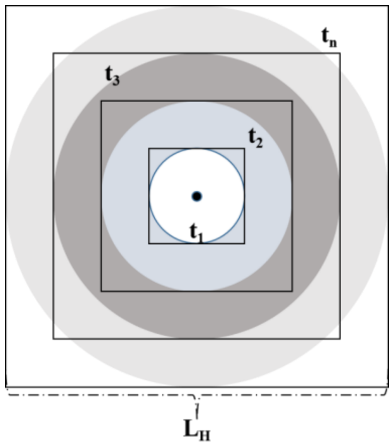

Fig. 5. The possible suggestions of the Z-energy flux rate with the side of the frame equal to the Hubble Length (i.e., the Z-Hubble, see Equation 44). Could Z be describing a pixel or a projector where energy diffusion flux occurs? The view here is eye-level with the arrow of time towards the viewer. Also notice that temporal gradations are enclosed. The time-like, static Universe is made up of multi-layered shells of space-like contemporaneous Universes of time t_1, t_2, up to t_n.

4 Discussions

4.1 A Possible Cosmogony?

If time Page and Wooters [3] (see also Figs. 1 and 3), time should be redefined to be independent of information influxes or from being optical occurrences; due to a localized photon cannot be everywhere along and every iso-temporal gradient (i.e., it has no infinite speed). This study has found that time is immaterial in Equation 24 when solving for a Gaussian radius. Yet, when solving for the smallest and largest temporal contours, this study learned that both the Planck and Hubble times are proportional to the square root of their respective Zs (see Equations 28 and 43). Note that from Equation 27, Z is proportional to an area with length L (see also Figures 5 and 6). If Equation 40 is true, then the determination of the total temporal contours of the Universe could be, let us say, simply dependent on a 2D flat polygon.

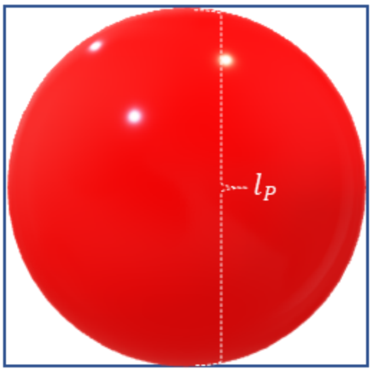

Fig. 6. The smallest geometry in the Universe is the Planck Area, here illustrated as a sphere. The corresponding Z-Planck is given by Equation 28.

Based on Equation 28, it can be deduced that the smallest possible area, known as the Planck Area, may either be represented as a pixel or a triangle (although this latter representation would be more complex than a simple square pixel). In contrast, note that a Z-Hubble implies a square and is a simpler polygon. What if the 2D polygon that a Z-Hubble implies may only represent a singular facet of a cube? Could this mean that the Universe be imagined as a sphere (Equation 41) inscribed within a box? (Please refer to Fig. 7 to see what this may look like.)

Yet, the enclosing box is non-wrinkled (non-contoured or non-graded) compared to the concentric, contoured Universe inside it. What does it contain? If the Universe is like a ballooned sphere inside a box (see Fig. 7), then, the whole physical existence is just within a cube (a Hubble cube)! In contrast, since the smallest 2D Z-energy flux (i.e., the Z-Planck) might be a square of side ℓP, could it be possible that the whole spherical Universe itself is made up of cubic voxels or 2D mini pixels? Imagine a sphere that is an energy aggregate of Planckian cubes or 2D pixels. Is reality a pixelated or voxelated Universe? And given Equation 40, time must be a pixel function (see also Equation 46). It could also be deduced that time exists because information sensing of internal observers is, in essence, mediated by light. The idea of time may have arisen from information being acquired via light. No internal observer could ever witness the Universe in its entirety.

4.2 Isotemporal Spaces and Quantum Entanglement

This study adopts Page and Wooters' concept of static time [3] as a non-superfluous or essential concept. The authors proposed the use of conditional probabilities interpretation to address the issue of time in systems such as general relativity and quantum mechanics. The reader is encouraged to consult their 1983 paper for further information. This paper applies the concept of static time ITP, which postulates that if time is indeed static, it must be finite and bounded. This should further imply that time in general is finite. ITP is valuable in providing insights into the possible shape of the Universe (as demonstrated by Equations 2, 38, and 41).

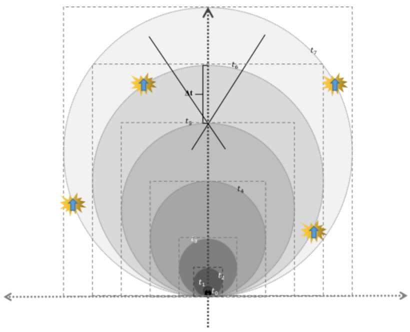

Fig. 7. Top view: The Universe is ballooning with time where each circular line is equitemporal. Quantum entanglement may be an equitemporal form of communication (i.e., always along the equitemporal line, say, t_4) that does not travel between or at an angle with the time-like direction.

The study also relies on the BGV theorem as a foundational concept. The theorem establishes that any universe that has, on average, undergone expansion throughout its history cannot have an infinite past but must have a past space-time boundary at its null point along its time-like axis. This informed the development of Equations 2 and 3 and subsequently led to the proposals of DTP and the idea of an expanding Universe. Additionally, the BGV theorem supports the notion that if the Universe is time-like, it can be viewed as a point within a vast Background. If the Universe is indeed time-like (as stated by the BGV theorem, 2003), then its $\Delta s^2 > 0$ or Δr^2 is effectively zero.

The Universe may look like a bubble of temporal layers within and along its entire history beginning in its null point up to its final age (see Fig. 1, 3, and 7). The surface of each bubble is what the static temporal isometric curves wish to depict – all particles that are on the same temporal curve belong to one single history. Note that the material or the gravitational mechanism of why the Universe has to be spherical is not suggested in this paper. With ITP assumed true, the Universe must have a proper timeline or age (see Fig. 7).

It can be reiterated that all points along an isometric curve associated with an effective present – an isocurve – are at the same temporal level. If this premise holds, it can be posited that communication through quantum entanglement (QE) can only be perceived when two particles are in an equitemporal state, or when they both occupy the same space-like axis, regardless of their spatial separation distance. QE communication may work only when the particles are iso- or equitemporal and do not travel at an angle with the time-like direction relative to the other. That is, both particles should always be equitemporal or belong to the same temporal surface. If this is true, then, two quantum entangled particles separated at extremely distant locations would have instantaneous communications if and only if they belong to an equitemporal contour. Traveling at relativistic speeds destroys the equitemporality of two supposedly quantum-entangled particles. If one of the particles were to travel at a relativistic speed while the other is at rest or moving at a normal pace, QE may not be observed.

In Fig. 7, you would notice that moving at the speed (at a 45° light line) makes one to move a significant arc displacement along the isotemporal line from the initial timeline, and time dilation happens. This may also explain why quantum mechanics seems time-dependent as time becomes characteristic of the particles once the measurement started. Whenever experiments are made, testers allocate an initial value (e.g., initial time) to register their data. A quantum measurement is recorded onto a present temporal curve that is shared by both the measurer and the quantity being measured. This is one of the underlying reasons why ITP assumes that time is observer-designate and inherently an artifice. Given ITP, time can be portrayed as isometric, actually invariant, but finite and no one could escape the final contour of time. Objects riding a common temporal level or time surface within the Universe can have different locations in space. Yet, all are just traveling on isometric levels that are moving toward the future at a certain rate.

4.3 Could Blackholes be Micro-Universes?

Could black holes have the same mechanism as the Universe – being energy diffused spacetimes (see Fig. 8)? Could they be micro universes that have their own distinct internal spatiotemporal systems, which sizes indicate their outermost limit and their intra-temporal system looks unchanging when viewed externally? To know how long a black hole gets to its diameter, say, the Messier 87*, which has a Schwarzschild radius (SR) of 1.9×10^{13} m (or 5.9×10^{-4} parsecs or 1.9×10^{-3} light-years), doubling its SR and dividing the result by the speed of light will be needed. The application of Equation 40 to black holes requires obtaining the square root of the corresponding Z-value, which is equal to $c^2 \cdot A$. Equation 45 is the simplest expression to solve for a black hole's proper time (see Fig. 8).

The side of the square inscribing the Schwarzschild circle is, thus, equal to its diameter, which is 3.8×10^{13} m. So, Messier 87* took only about 35 hours to completely become a black hole. This means that for any observer inside Messier 87*, no lifetime can exceed 35 hours. Another expression of Equation 40 to get the time for a black hole to reach its present state is

$$t_{black} = \frac{\sqrt{A}}{c} \tag{45}$$

where A is the 2D square area enclosing a stellar body. One can use Equation 45 to solve for the internal proper time of a black hole if they are simply micro universes and may as be a good example of time being stationary. If Equation 16 is valid, it cannot be known with high certainty together a certain stellar mass and the spatial area that immediately surrounds it. Thus, area A cannot be expressed in terms of mass in Equation 45.

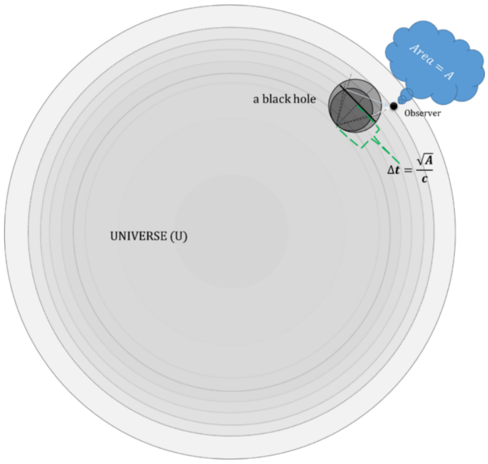

Fig. 8. A simplified side view of the static 4D Universe hosting a black hole – a possible micro-universe itself. The time for the black hole's Schwarzschild radius to reach its size could be estimated by simply dividing its diameter by c (see Equation 45). Notice that the origin of the black hole is depicted to originate below its observed area A just like the Universe that has its point of beginning relative to internal observers.

4.4 A Timeless Reality Outside Spacetime

As per Equation 24, time is inconsequential outside the smallest possible radius ℵ of the Universe – given Equation 13 and Equation 23 (Energy Uncertainty Principle). Even if the energy diffusion of the Universe (see Equation 16) is assumed to be dynamic, Equation 24 still stands. Thus, from the smallest to the largest lengths, time is insignificant. It would be best to say that there is no external spacetime for the Universe to start beginning.

Thus, since there are no processes (i.e., timeless) outside of its limits, the Universe could be timeless information with defined boundaries. And unlike blackholes which reside within spacetime, the Universe exists out of nothing. It is a spatiotemporal island existing from a timeless and spaceless Background. This Background is non-physical and could neither be neither penetrated nor could material objects move through it. It must be immense in size but it neither is space nor time.

If postulates ITP (invariant time postulate) and DTP (dynamic time postulate) are both true, it must be accepted that the Universe is limited. If it must be maintained that the Universe is an energy-diffused, spatiotemporal body that is finite, small, statically temporal, or wrinkled, then it must be unique in relation to the timeless Background. Otherwise, there would not be any differentiation and the aforesaid assumptions crumble. If this Background is wrinkled too or has equitemporal contours, the Universe (U hereon) could not be distinguished and this will make our assumptions false and our derivation of the Planck and Hubble Time to be invalid.

Since U is wrinkled or temporal, then, the Background should be noncontoured or timeless. If the internal Universe has processes, then, the background should be without process or unchanging. If it is small and finite, then, the Background should be vast or possibly infinite. To differentiate U from this Background (similar to TEO), to maintain that $dr \to 0$ or U is time-like since this study also holds this assumption to be valid as suggested by the BGV theorem [3], then, it could be inferred that TEO may have the following characteristics:

a. An immense background;
b. Unchangeable as opposed to the internal temporality of U, which means
c. Not experiencing a change in size and contents; and,
d. Contourless (i.e., simpler) relative to U's temporal levels.

Note that these are necessary descriptions for TEO to maintain the idea that $dr \to 0$ or U is time-like given it is static or stationary (Page and Wooters 1983).

So, relative to an unchanging TEO, the temporal contours inside U are invariant and static. It is wont to think of U as if it started to appear from nothing or being-not there (see Fig. 9A). But this presupposes that information or what TEO "contains" changes and is solely optical (i.e., from being invisible to visible). Every assumption about TEO depends on the veracity of $dr \to 0$ or U being time-like. To answer whether the entire timeline of the Universe began to appear or not at all, let us first discuss its uniqueness.

4.5 The Universe is Uniquely Contoured

If the temporal contours (illustrated as pixel U in Fig. 9 and 10) are internal only for U and nothing of these describes the vastness of TEO, then static time does not extend beyond U and must appear to flow for all internal observers whose velocity and information access is less than and dependent on the speed of light (ITP). If ITP is true that TEO is simple (i.e., contourless) and does not change (i.e., timeless), then, its reality should not sum up to A+B. Thus, Fig. 9 is not a sound illustration. Fig 9 caricatures the prevailing idea amongst creationists of how the Universe began to exist. And it fails, at least, in two aspects: (1) TEO's contents and (2) size did change if TEO's traits stand. So, to correct Fig. 9, TEO should always have U and its size should not have changed to A+B (see Fig. 10).

Fig. 9. The usual assumption for the Universe: TEO at (A) pre- and (B) post-appearance of U of age 14 billion years old (BYO). The point-sized Universe U is exaggerated in B for emphasis. The immense TEO is illustrated as the larger square for simplicity.

Fig. 10. TEO timelessly contains U. If U is wrinkled and since TEO is smooth and simple, TEO must be timeless and processless. Notice that TEO is not sequential to be A+B and U is eternally wrinkled as ~14 billion years old (i.e., 14 billion 1-sec static gradation) because the contours are invariant or increasing.

Since TEO is timeless or unchanging, U as information should always be present before TEO (Fig. 10). Notice that TEO is not rated as 14 billion years old because it is not contoured, and experiences no sequences as A to B. It should always be remembered that even if TEO "contains" U, it must be different from U (since U is finite) and not be the same as the latter. The uniqueness comes from the fact that TEO is unwrinkled while U is which implies a difference in their substances. If TEO>>>U in terms of size (assuming $\Delta r \rightarrow 0$, see Equation 1), then, the absolute ratio of U vis-a-vis TEO is practically zero:

$$\left|\frac{U}{TEO}\right| = \left|\frac{\Delta r^2}{TEO}\right| \equiv 0 \tag{46}$$

Equation 46 is another implication of ITP and should cohere with the idea. If all of the time is simultaneous within the Universe, then, its age is invariant due to its static internal temporal contours, which are not shared by the non-contoured TEO. This implies that even if the universe (U) has always been in existence alongside TEO, the latter would not have a defined age due to its lack of internal temporal contours. Now, if TEO's age were referenced to that of U, it would still be more than 14 billion years old simply because of its immense size. This would render TEO's years uncountable as it has no known boundary or point of beginning, unlike U where its $dr \rightarrow 0$ relative to TEO. And TEO must be noncontoured making its contents, information, and size never change. Hence, this means that TEO is processless or unchanging. As suggested by this study's postulates, U is timeless information to TEO yet 14 billion years old given its internal contours. Temporal contours or wrinkles make U age but not TEO.

Even if extending the universe's (U) temporal contours to TEO, TEO would still possess an incalculable number of contours. Yet, that violates the idea that U is time-like and $dr \rightarrow 0$. If TEO was also wrinkled, U becomes indistinguishable and $dr \neq 0$, a violation of the BGV theorem (2003). If that is the case, the Universe (U) would have no external boundaries and would not be time-like.

The Universe seems to begin to exist for internal observers as information is not given instantaneously and access to information is mediated by the limitations of the speed of light. The need for ITP arises from such a limitation. If everything is externally timeless vis-à-vis wrinkled universes like U, this means that their existence does not need a literal time. TEO's contents or information are not dependent on optics, and thus, independent of time (see Equation 40). That is, universes are timeless contents in TEO. Lagged information exists due to optics being what subluminal agents are dependent on.

4.6 Is Time an Optical Illusion?

Temporal contours can be thought to exist (given postulate ITP) due to internal processes in U and can act like bumps that impede the acquisition of data or information. Physics-wise, for the processless TEO, no information begins to exist. If Equation 40 is true, beginnings are limited by a factor of c^2 – as time is inversely proportional – and must imply that it is rooted in optics. A beginning only appears when light carrying the data travels and later informs an observer. If information is conveyed by light, then, U must appear to have a beginning for all subluminal internal observers. A simple modus ponens argues for this:

1. Any access to information is mediated by light.
2. The beginning of time is a piece of distant information.
3. P1 and P2 are true.
4. Ergo, access to the beginning of time is mediated by light.

It is known that light does not travel to any point within the Universe instantaneously. Access to distant information is gradualistic and requires an incremental flow of data. The information does not come all at once and so this made us believe that time is ontological. Yet, if ITP is true, information tends to be timeless. Our limited epistemology only fails to inform us. Thus, the Universe appears to have a beginning not because it is its nature but because of our characteristic epistemological limitations. Conscious beings have a massive dependence on light. In this regard, this inquiry suggests that time may just be an optical phenomenon. Our consciousness itself seems to cannot go faster than light and maybe forever dependent on it.

5 Conclusions

This study outright takes as true the idea that the Universe is under a time-like direction along its spacetime plane [3] and that time could be taken as static [4]. That if these were valid, then the Universe could be divided into contours or gradations which this study equated or described as temporal isometric curves (or, static temporal contours). If the Universe is static, then, these isometric lines could also be considered invariant to an external observer but flowing for internal ones (whose access to information is primarily mediated by the speed of light). With this as a leeway, Δs was divided by Δt and so this study arrived at Equations 13, 16, 24, and 27, down to Equation 45. Combining this study's two postulates (i.e., the ITP and DTP), the Planck (Equation 42) and Hubble (Equation 44) times were derived using an equation that is directly proportional to a factor called Z (see Equation 41). It is realized here that Z could either be a Planck Length or a Hubble Length-dependent factor (Z-Planck and Z-Hubble, respectively) with a general expression of $c^2 \cdot L^2$. Also, from ITP, this study arrived at an Energy Diffusion Uncertainty Equation (Equation 16), which is related to the Energy Uncertainty Equation [8] and Einstein's mass-energy equivalence [7], which makes Equation 12 possible. Could Equation 16 solve the dark matter and dark energy dilemmas? The dissonant H_0 values between the theoretical and experimental could come from an uncertainty limit given by Equation 16.

Also, given DTP, the rate of energy diffusion ε should accelerate at the speed of light squared c^2. Perhaps, relative to internal observers, this energy diffusion acceleration (that was found to be related to the rate of the Hubble expansion, see Equation 35 to 44), maybe is more than enough to drive spatial area changes that make future events within the Universe to be undetectable by light-dependent observers. This means nobody could observe future events that are even just 1 second away from the present given Gauss's Law of Energy Diffusion (EDF). EDF drives the spatial area change to be a one-directional vector – always away from the hotter beginning towards the colder dead end. The invariant time postulate (ITP) provides an idea about the size or the limits of the Universe while the dynamic time postulate (DTP) relates to how the Universe could reach that size.

Yet, even if time is assumed invariant, if ITP is true, this study has found that time ultimately drops out of the equation when looking for a possible value for the characteristic radial length ℵ (where $\aleph \geq \ell_P$) while using Gauss' Law for Energy Diffusion Flux (EDF) over an enclosed sphere – a supposedly dynamic time assumption. Thus, it is found that time is irrelevant for such scales beyond ℵ or L_H. Notice the rate of change of energy diffusion flux Z as $c^2 \cdot L$ is similar to the denominator of the Bekenstein Limit for information or information entropy if L is taken as the Planck Length ℓ_P. Also interesting is the factor ℓ^2 that could be considered as a window area through which the energy diffusion flux can occur. This work suggests a cosmogony for the Universe. That it could be imagined as a set of static spheres (see Equation 41) that has initial and final temporal curves. Time, including Planck's or Hubble's, is considered synthetic, and assigning gradations over a static Universe is permissible. Planck's represents the minimum possible limit that can be assigned to the Universe and Hubble's represent its largest counterpart. If this study is to be believed, the Hubble time is the Universe's maximum possible age.

In conclusion, the derivation of the Planck and Hubble times via a single equation (Equation 40) appears to have been successful because of the assumption that the Universe is made up of invariant isometric curves (given ITP). Inadvertently, this somehow showed that the time-absolutists and time-is-an-illusion views could be compatible. The Z factor needs to be further explored for its possible connection to information physics, especially with Bekenstein's optimal information theory. The synthetic time wrinkles or temporal contours along the time-like direction can be described by either Equation 4, 40, or 45, which supports ITP. The space-like axis can be considered as temporal latitudes parallel to each current version of the Universe. Flat spacetime grids (i.e., normal to the time-like direction and parallel to the temporal latitudes) are where EDF passes through. And two internal observers that are within the same flat spacetime grids are concurrent. If they are not on the same contour planes, their times should be different. That is, two observers have simultaneous time if they occupy the same isometric curve. A perfect light-like motion intersects the equitemporal lines from a 45° angle. An application of isometric curves (or the static temporal contours) as equitemporal surfaces may be related to quantum entanglement where the travel speed of communication is instantaneous if and only if two or more entangled particles are riding the same temporal contours. Moving the other particle at relativistic speeds will break the entanglement.

If Page and Wooters's idea [4] is true, then, it can be said that the Universe is finite and static compared to its timeless and spaceless background. ITP and Equation 46 show that the Universe's age should not affect TEO because (1) the Universe alone is wrinkled with static temporal contours and (2) their sizes are not the same. This inquiry also tried to show that accepting ITP and Δr to be zero (i.e., the Universe is time-like), assuming the BGV theorem [3] is true, it could be said that time is simply an artifice since information must be (1) transcendental and it is (2) not fundamentally dependent on optics. Subluminal detection of information (i.e., for humans) thus happens across space. And that creates the illusion of time.

Hence, the Universe is not growing. It has a beginning and an end that existed timelessly. The human information vector is directed against the forward direction of past lights, opposite to the vector of energy diffusion fluxes (see Equations 17 and 18), so the logical flow of events carried by light is interpreted unidirectionally. Information carriage via optics makes us experience pauses, intervals, and, finally, time. The popular phrase "whatever begins to exist has a cause" does make sense only for subluminal consciousness because information can never be acquired infinitely fast within the Universe. Time is but a consequence of light and an extremely useful fiction. For that matter, a timeless beginning (a static spatiotemporal edge) does still have a cause. And the cause must be processless or timeless.

Let Bryce DeWitt summarize this whole paper when he said in the 1960s that

"Other times are just special cases of other universes."[12]

Acknowledgment

I dedicate this study to Christine, my wife, whose motivation and support are encouraging. I dedicate this study to Ian, my brother, who first heard of this idea way back in 2007 and who encouraged me to publish it. I dedicate this work to my parents and to my sister Steph.

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