ENTANGLED 2S+T BIDIRECTIONAL-TEMPORAL SPHERICAL QUANTIZED GRAVITATIONAL ENERGY

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***Abstract*—The current paper is a proposed model for quantized gravitational energy, which is theorized to propagate as 2S+T quantized spherical surfaces in spacetime, at the speed of light, emitted from a source as entangled pairs of bidirectional-temporal propagating expanding and contracting boundary surfaces in spacetime - these spheres herein defined as *Eide spheres*. These Eide spheres, are furthermore proposed to be the fundamental source of quantum entanglement entropy that gives rise to the fabric and geometry of 3S+T spacetime in the higher dimension bulk. Eide spheres existing as an infinite number of 2S+T quantum boundaries throughout the Universe, creating an infinite network of 2S+T entanglement entropy. The Spherical Gravity (SG) theory of Eide spheres establishes the postulate - *quantized gravitational energy and boundary quantum entanglement entropy are inseparable in observation*. From this fundamental postulate, all the key properties of Eide spheres are derived.**

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I. QUANTIZED SPEED OF LIGHT RING IN 3D MINKOWSKI SPACETIME TO QUANTIZED SPHERICAL GRAVITATIONAL ENERGY IN 4D SPACETIME

Theorizing on how quantized gravitational energy may move through spacetime, we start with visualizing the propagation of the graviton in Minkowski spacetime for a simplistic relativistic framework.

The motions and visualizations of photons in Minkowski spacetime show that the messenger particles of the electromagnetic force propagate in every spatial direction through spacetime at the speed of light and away from the emitting source. The speed of light constant, measured from any inertial reference frame (regardless of the motion of the observer or emitting source), is one of two postulates of Einstein's Special Relativity. It shows that while motion through space or time is relative to the motions of the object and observers, all inertial observers still must agree on the total motion an object has through spacetime. In other words, Special Relativity shows that all objects move through spacetime at the speed of light, the speed of causality - it is a question of how much of that motion is observed in space and how much is observed in time.

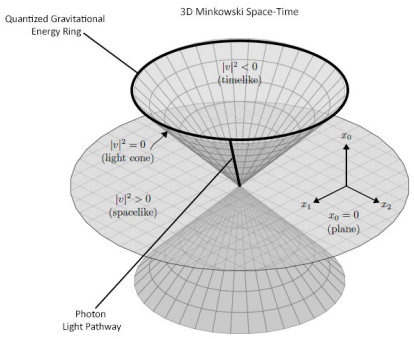

Fig. 1. 3-dimensional Minkowski space-time for two spatial dimensions and one time dimension.

Photons, as massless particles, travel along null geodesics, meaning they do not experience the passage of time along their worldlines, whereas particles with rest mass have motion through space and time. Moving at the speed of light, these photons carve out light cones in 3D (2S+T) Minkowski spacetime with a past light cone in the negative (backward) time direction and a future light cone in the positive (forward) time direction, measured from the emitting source, as shown in Fig.1. These light cones define the spacetime boundaries of causality for the set of events that occur within them.

The theorized graviton is anticipated, based on Einstein's General Relativity calculation of gravitational waves moving at the speed of light, to likewise propagate at the speed of light. In 3D Minkowski spacetime, this would mathematically carve out a "gravity cone" that overlaps light cones. Light cones built from the 45° degree light paths of the photons from an emitting source, when plotted 2S against cT (shown in Fig. 1. as a 'photon light pathway'). This paper departs from this assumed geometrical sameness of graviton and photon paths in Minkowski spacetime and proposes that quantized gravitational energy propagates in Minkowski spacetime not like a single quantized light path, but propagates as a single quantized graviton ring through a plane of the light cone, as shown in Fig. 1. In this geometric form, the propagation speed is still the speed of light, but the quantized gravitational energy, or graviton, has a more unique non-localized information form from the perspective of observers.

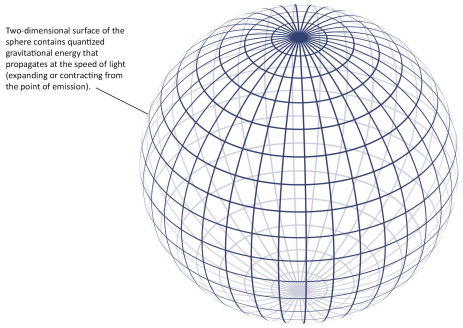

Fig. 2. Eide sphere - two-dimensional surface of the sphere contains quantized gravitational energy that propagates at the speed of light in flat space-time.

While Minkowski spacetime traditionally loses a space coordinate in favor of visualization of the time dimension (multiplied by the speed of light), this theoretical ring model of the graviton can be expanded into four-dimensional 3S+T spacetime as a two-dimensional spatial spherical surface, moving radially outward at the speed of light, as shown in Fig. 2. It is additionally theorized that quantized gravitational energy could be emitted in this form with bidirectional-temporal motion for expanding spheres (forward time motion) and contracting spheres (backward time motion).

It should be noted that the motion of contracting spheres

only appears contracting from the perspective of forward time motion. For an observer moving in the backward time motion, backward time spheres appear as expanding and the forward time motion spheres appear as contracting. These spheres are only designated as expanding and contracting because in this paper we will always be analyzing their propagation from the perspective of forward (or positive) time motion, as we traditionally measure as observers in our Universe. The expanding and contracting spheres are theorized because just as photons are emitted in every spatial direction from a source, the emission of gravitons, in this model, would be in every temporal direction from a source. And being non-localized within the relativistic framework, would always occur as pairs of quantized entangled spherical surfaces.

A geometric interpretation for the observance of this form of quantized gravitational energy could be viewed relativistically from the two-dimensional surface of the sphere as having all motion in time and no motion in space. The quantization to the entire surface of the sphere is a result of the graviton energy having no bias for any spatial localization, so all spatial points possible in ct (or $-ct$) distance from the emitting source are equal and traversed, from the perspective of any observer. So there is not a single quantized radial pathway but instead a single quantized radial surface.

This simplistic thought experiment on how quantized gravitational energy may propagate in an inertial relativistic framework aids in the visualization of Eide spheres, but in the next two sections we consider the potential internal energies and spacetime near a black hole for non-inertial reference frames.

II. SIMPLISTIC DERIVATION OF QUANTUM GRAVITATIONAL INFORMATION CONTRIBUTION OF A BLACK HOLE TO ITS EVENT HORIZON

The origin of black hole entropy lies in the $Bekenstein-Hawking$[1,2] equation (1), which solves to find the entropy of the black hole is dependent on, and proportional to, the surface area of the event horizon and not the volume of the black hole. This is in stark difference to the thermodynamics of a gas where its entropy is dependent on the volume of the gas, and not the surface area. The dynamics of the internal energies of the black hole are considered next.

$$S_{BH} = \frac{k_b A}{4 l_p^2} = \frac{c^3 k_b A}{4 G \hbar} \tag{1}$$

Equation (1) gives the $Bekenstein-Hawking$ or *Black Hole* (S_{BH}) entropy, where c is the speed of light, $\hbar$ is Planck's constant divided by 2π, G is the gravitational constant, l_p is the Planck length, and A is the surface area of the event horizon of the black hole.

The relation between the event horizon surface area and the black hole entropy allows us to study the potential internal energies of the black hole and their contributions to this surface area. We can start with the Schwarzschild radius of a simple, non-rotating black hole where charge and angular momentum are zero and we only consider the total mass of the black hole. The Schwarzschild radius can be calculated as,

$$R_s = \frac{2GM}{c^2} \tag{2}$$

Equation (2) gives the Schwarzschild radius, R_s, of the black hole, where G is the gravitational constant, M is the total mass of the black hole and c is the speed of light. We model this black hole as being made of a finite number of Planck masses (m_p). With mass being the source of gravitational effects, and if quantum gravity is realized, we assert that each Planck mass would require at least a single quantum messenger to communicate its mass energy. Otherwise, a single Planck mass unit could exist with no quantum gravitational effect. We first rearrange the equation as,

$$R_s = \frac{2G n_m m_p}{c^2}, \tag{3}$$

where we have replaced the total mass M of the black hole with m_p, the Planck mass, and n_m, the total number of Planck masses. This can also be equated with constants by using the relation,

$m_p = \sqrt{\frac{\hbar c}{G}}$, so now we have the equation,

$$R_s = \sqrt{\frac{\hbar c}{G}} \frac{2G n_m}{c^2} \tag{4}$$

We can further evaluate the Schwarzschild radius in terms of Planck units by evaluating the length of the radius as $R_s = n_l l_p$, where l_p is Planck length and n_l is the number of Planck lengths. This can also be equated with constants using,

$l_p = \sqrt{\frac{\hbar G}{c^3}}$, we equate these terms as,

$$n_l \sqrt{\frac{\hbar G}{c^3}} = \sqrt{\frac{\hbar c}{G}} \frac{2G n_m}{c^2}, \tag{5}$$

Based on equation (5), we can see that the entire relation reduces down to a simple equation between the total number of Planck masses of the black hole and the total number of Planck lengths of the Schwarzschild radius as,

$$n_l = 2 n_m \tag{6}$$

This proposes a potential fundamental Planck relation to the total mass of a simple, non-rotating black hole and the length of its Schwarzschild radius - f*or every Planck mass, there is a corresponding emergence of two Planck lengths to the Schwarzschild radius*. Relating the Schwarzschild radius as $n_l l_p$ and equating to the surface area of the event horizon of the black hole, we can relate the following as,

$$A = 4\pi R_S^2 = 4\pi (n_l l_p)^2 \quad (7)$$

We can further replace n_l with our derived equation (6) for the relation between number of Planck masses to Planck lengths, so that the surface area of the event horizon can be calculated from the number of Planck masses that make up the total mass of the black hole as,

$$A = 4\pi (2n_m l_p)^2 \quad (8)$$

Returning to our understanding that at least one quantum messenger is required to communicate the mass energy of a single Planck mass, we replace the number of Planck masses, n_m, with the number of quantized gravitational energy messengers, or gravitons, n_g, and rewrite the equation as,

$$A = 16\pi (n_g l_p)^2 = 16\pi n_g^2 l_p^2 \quad (9)$$

We have now derived a very simplistic equation which potentially calculates the surface area of the event horizon of the black hole from the number of gravitons emitted from the mass of the black hole. Using this equation, we calculate the area contribution to the event horizon of the black hole for one graviton as,

$$A_{(n_g=1)} = 16\pi l_p^2 \quad (10)$$

The result of equation (10) gives a potential relation of finding the lowest possible quantized source of an area contribution to the total surface area of the event horizon. It is noted that this contribution is geometrically spherical, with the emergence of 16π and the squared radial element of l_p^2. This spherical contribution of $16\pi l_p^2$ potentially gives support to the theory that Eide spheres could be carrying the quantized gravitational energy from mass energy like that found in the black hole. It is noted, this derivation has been performed under a very simplistic framework, a complete quantum field theory of Eide spheres would be needed to confirm or invalidate this theorized quantized contribution.

In equation (11), we can further calculate for the potential entropy contribution to the surface area of the event horizon of the black hole as expressed by Universal constants and the number of gravitons squared.

$$S_{BH} = \frac{k_b A}{4l_p^2} = \frac{c^3 k_b A}{4G\hbar} = \frac{c^3 k_b 16\pi n_g^2 l_p^2}{4G\hbar} = 4\pi k_b n_g^2 \quad (11)$$

We find the equation reduces simply to 4π multiplied by Boltzmann constant k_b and multiplied by the number of gravitons squared. In calculating for the contribution of black hole entropy by a single graviton, we find it is simply $4\pi k_b$, as calculated in equation (12) below.

$$S_{BH(n_g=1)} = \frac{c^3 k_b 16\pi l_p^2}{4G\hbar} = 4\pi k_b \quad (12)$$

While this very simplistic and theoretical derivation of quantized area contribution of a black hole mass energy to its event horizon surface area provides potential support in the consideration of the possible existence of Eide spheres in a non-inertial reference frame, exploring the spacetime metric itself for above and below the event horizon of a black hole gives a non-local, non-inertial consideration. As discussed in the next section.

III. SPATIAL AND TEMPORAL ELEMENTS OF THE SCHWARZSCHILD METRIC ABOVE AND BELOW THE BLACK HOLE EVENT HORIZON

One of the earliest solutions to Einstein's General Relativity field equations was solved for by Karl Schwarzschild in 1916, shown in equation (13). In this solution, we can set the charge and angular momentum to zero so that only the mass is contributing to the entropy of the black hole, shown in equation (14).

In this equation, r is the distance from the black hole, r_s is the Schwarzschild radius, dr is the change in space as observed for an object and dt is its change in time. This calculates the objects overall change in spacetime, or its spacetime interval $d\tau$. At very large r, the Schwarzschild metric reduces to the flat Minkowski spacetime interval.

$$g = -c^2 d\tau = -(1 - \frac{r_s}{r})c^2 dt^2 + (1 - \frac{r_s}{r})^{-1} dr^2 + r^2 g\Omega \quad (13)$$

In equation (13) where $g\Omega = (d\theta^2 + sin^2\theta d\phi^2)$ is the 2-sphere term, this can be set to zero for the case of a simple, non-rotating black hole with zero charge and zero angular momentum, so then we have,

$$-c^2 d\tau = -(1 - \frac{r_s}{r})c^2 dt^2 + (1 - \frac{r_s}{r})^{-1} dr^2 \quad (14)$$

Equation (14) is for a simple, non-rotating black hole and can be used to study how an object experiences spacetime as it moves from above to below the event horizon. We can first

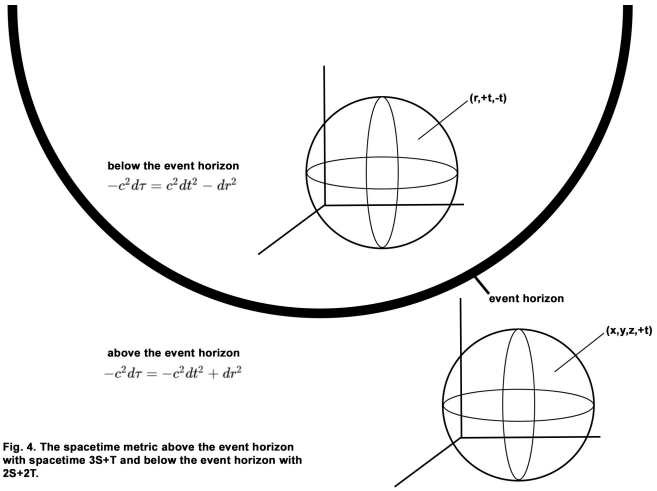

Fig. 4. The spacetime metric above the event horizon with spacetime 3S+T and below the event horizon with 2S+2T.

start by looking at terms where r is greater than r_s , where the equation takes a general form of,

$$-c^2 d\tau = -c^2 dt^2 + dr^2 \text{ (where r > } r_s\text{, above the event horizon)} \quad (15)$$

We can see that spacetime causality is driven by the negative temporal sign of the $-c^2 dt^2$ element of the metric, as shown in Fig. 4. An object moving through spacetime in this form is experiencing space and time in the traditional sense of how we move through spacetime in our Universe. Its motion in 3S+T has a unidirectional motion in time that preserves causality. In other words, an object may stay fixed at a spatial coordinate but its motion through time must continue and is required for the spacetime interval to evolve. Next we can study the object as it falls below the event horizon.

Below the event horizon, r is now less than r_s and the general form of the metric changes, as shown in Fig. 4 and equation (16). With r less than r_s, we can see the temporal element has flipped signs. The temporal element was previously unidirectional and driving the causality of the spacetime equation, but has now become the "spatial" element. Likewise, the spatial element that was previously bidirectional has now become the "temporal" element, flipping its sign as well, mathematically driving the causality of the spacetime interval below the event horizon. This result shows an object moving below the event horizon of the black hole will experience spacetime in one direction of space, the radial direction, and bidirectional in the time dimension.

$$-c^2 d\tau = c^2 dt^2 - dr^2 \text{ (where r < } r_s\text{, below the event horizon)} \quad (16)$$

This is an important consequence - above the event horizon, causality of spacetime was driven by the unidirectional time element of the Schwarzschild metric, but below the event horizon, it is the radial element driving causality, as any object in this spacetime will have no choice but to move in the radial direction for the metric to evolve, and for causality to be preserved. Below the horizon, the time dimension is now bidirectional in the positive and negative directions.

This is an important feature of how spacetime exists below the event horizon as these allowed spatial and time motions match exactly the quantized gravitational energy motions of Eide spheres, as described herein. The Eide spheres propagate only in the radial direction for the spatial dimension (and must move in this direction) but can move either in positive time direction (forward or expanding) or negative time direction (backward or contracting).

This is potential geometric support for the possible existence of Eide spheres that would theoretically saturate the spacetime below the event horizon of a black hole. And as will be discussed in the next section, may be responsible for giving rise to 3S+T spacetime and its respective geometry in the bulk, which would help explain this behavior of the shifting of the spatial and temporal elements of the spacetime metric below the event horizon.

IV. NON-LOCALIZED 2S+T INFORMATION OF EIDE SPHERES EQUATED TO BOUNDARY ENTANGLEMENT ENTROPY

The theoretical model of Eide spheres as quantized gravitational energy propagating as pairs of entangled 2S+T spherical surfaces, is fundamentally non-localized information from the quantum and relativistic frameworks. This non-localized information is geometrically and mathematically equated to 2S+T surface (boundary) entanglement entropy, occurring between pairs of entangled Eide spheres, one expanding and one contracting from an emitting source. Each entangled pair of Eide spheres could possibly be seen as a minimal unit of boundary entanglement entropy relating to a fundamental unit of geometry in the bulk. An infinite number of 2S+T Eide sphere boundaries could then possibly encode all the spatial relationships and geometry of the 3S+T spacetime in the bulk.

There would be a unified elegance to this if it were true - the boundary entanglement entropy that gives rise to spacetime in the bulk also dictates the geometry of this spacetime, being also the quantized gravitational energy that carries the information of the mass energy in spacetime.

This illuminates the final picture of the theoretical Eide sphere model where gravitons envisioned as Eide spheres could potentially be both quantized gravitational energy and the source of boundary entanglement entropy - the latter being composed of an infinite number of Eide sphere quantum boundaries. This could possibly give rise to discrete spacetime geometries that in the bulk could potentially approximate to a theory of gravity that on large scales is an emergent continuous geometry of that spacetime. This could possibly approximate to the large scale formulation of Einstein's General Relativity.

Furthermore, this establishes a new postulate - *quantized gravitational energy and boundary quantum entanglement entropy are inseparable in observation*. It's important to note the distinction between the theory of Eide spheres and Einstein's General Relativity. GR is based on the theory that mass energy curves spacetime, whereas Eide spheres (ES) could find that mass energy is not inherently curving *existing* spacetime, but rather, it is giving rise to 3S+T spacetime itself, and in process establishing and defining the geometry of this spacetime. Removing mass energy from the Universe in the theory of ES from the Universe could remove not just the affected geometry of spacetime (as in the result of GR) but could also remove 3S+T spacetime itself in the bulk.

While fundamentally different, this potential bridge between a lower boundary composed of a quantum mechanical network of entropy entanglement boundaries to discrete geometries of spacetime in the bulk could possibly provide a direct quantum mechanical interpretation of Einstein's spacetime curvature.

We can use the above established postulate to visualize a potential relation between the von Neumann entropy as measured in the 3S+T bulk to the quantum entanglement entropy of the Eide spheres - a network of entangled 2S+T discrete boundaries.

$$S_{geometry} = -\int d^3r\ Tr\ (\rho(\hat{r},t)\ log\ \rho\ (\hat{r},t)) = n_g \frac{c^3 k_b}{4G\hbar} \int |\psi(\hat{r},t)\psi(\hat{r},-t)|^2\, d^3r \qquad (17)$$

In this form of equation (17), we can see a potential relation of the 3S+T bulk entropy equated to the 2S+T quantum entanglement area of the pairs of expanding and contracting entangled Eide spheres. It is noted, this is a very simplistic equation to help in beginning to visualize these potential relationships. A full quantum field theory of Eide spheres would be needed to find all potential aspects of these relationships, possibly including such details as the specific forms of the Eide spheres wave functions, the full mechanism of entanglement, and the full impact of the quantization of the spherical surfaces.

This equation potentially aligns with the work of Mark Van Raamsdonk in which it has been found that the entanglement entropy between two quantum states of a boundary quantum field theory is related to the area of the minimal surface in the dual geometry, such that the boundary of the minimal surface coincides with the boundary of the entangled quantum states.

V. Origin of Eide Spheres Model - Lighthouse Paradox & Expansion of the Universe

The Lighthouse Paradox occurs when an observer views the spreading of photons of light across a surface at a rate that is faster than the speed of light. The thought experiment conjures the illusion of a rotating lighthouse, sending out radial photons that sweep through an arc. In this motion, the first propagated photons can be observed to hit a position A on a distant surface and then a following group of photons to hit a position B on the same surface, the result of the emitting source being rotated on its axis. If the distance from the source of emission and the surface, and the rate of rotation, is such, the viewed illumination of position A followed by position B can occur at a rate that is observed faster than the speed of light.

While this may seem to an observer as a violation of Einstein's Special Relativity, in which the speed of light is a constant in any inertial reference frame, the paradox can be resolved by identifying that no information has truly traveled from position A to position B. The photons of light are only traveling from source to position A, and from source to position B, both at the speed of light, never violating the speed of light constant - no photons travel from position A to position B.

This is a well published resolution to the paradox, however, it should be noted that the observer who tracks the perceived faster than light illumination across the surface where position A and position B lie, requires a non-parallel field of view of this surface. An observer viewing parallel to the surface will not be able to see the perceived effect. This is because while the photons can be traced out in Minkowski spacetime light paths along single lines of propagation, the cumulative effect of the perceived faster than light illumination must occur on a two-dimensional surface. This is an important geometric consequence and is foundational to the origin of Eide spheres.

In the early 20th century, it was discovered via astronomical observation and solutions to the field equations of Einstein's General Relativity that the Universe is expanding. The expansion is observed in the non-gravitational bound spacetime of the Universe where at great distances, the rate of expansion is perceived greater than the speed of light. This observance is reminiscent of the perceived illumination, or superluminal velocity, of the Lighthouse Paradox and establishes the first thought experiment in the origin of theoretical Eide spheres.

If we align with the resolution of the Lighthouse Paradox, we can theorize that the expansion of spacetime is not the result of quantized spacetime constituents moving faster than the speed of light, but is the result of a cumulative effect of observed superluminal velocity of underlying quantum constituents that give rise to the observance of spacetime expansion. There are, however, two important distinctions between the Lighthouse Paradox and the expansion of the Universe: a.) the Lighthouse Paradox is dependent on the angle of observance to the illumination effect established between two points on the surface where superluminal velocity occurs whereas spacetime expansion is observable from any angle an observer may take in the Universe, and b.) the superluminal velocity of the Lighthouse Paradox occurs on the observed surface of interaction whereas the expansion of the Universe occurs in the observed volume of interaction.

These are important distinctions that are two key insights into the origin of Eide spheres. In point a.) above, the resolution of identifying quantum constituents that can propagate and give rise to spacetime expansion, regardless of the angle of observance, requires careful geometric consideration. There is a thoughtful deviation from point like particles that trace world line paths in Minkowski spacetime - as in the case of the photons that travel across the surface of the Lighthouse Paradox.

The question is asked - what geometrical construct can allow one to always see the 'surface of illumination', regardless of angle of observation? Returning to the Lighthouse Paradox, we can see that the loss of observance of the superluminal velocity was a consequence of the angle of field of view of the surface. When the observer was parallel to the surface, the effect was no longer viewable. Taking the position of an observer and allowing them to rotate in any possible angle of view, there is only one geometrical construct of quantization that would ensure any world line path from the position of the observer would interact orthogonal to the effect of superluminal velocity or 'surface of illumination' - when the observer is at the center of a two-dimensional sphere. An observer inside a 2D sphere would always be viewing the 'surface of illumination' (i.e. propagation of quantized spheres in the 3S+T of spacetime), regardless of their angle of observance (i.e. the observer can rotate in any direction and for any amount of time). It should be noted that this relation is geometrically conformal - angle-preserving transformations in spacetime, but not lengths. Which further agrees with how the Hubble expansion of the Universe is observed.

In point b.) above, while photons illuminate the observed surface, the quantum constituents giving rise to the observance of faster than speed of light expansion of spacetime are possibly giving rise to spacetime itself and its respective geometry. In other words, while both effects are creating an illusion of faster than light travel of information, the photons do not accomplish this by creating more surface of the interacting area, whereas the quantum constituents of the expansion of spacetime would be giving rise to an increased observance of spacetime itself, as it is currently understood in cosmology from the experimentally observed spacetime expansion of the Universe.

In applying the geometrical resolution of the Lighthouse Paradox to the expansion of the Universe, we arrive at the geometrical conclusion that if the expansion of spacetime at faster than light speed is an observed effect of quantum constituents and not a violation of Einstein's Special Relativity, those quantum entities would propagate as spherical surfaces. This would preserve angles but not lengths of observation of the perceived effect and would place these quantum constituents at a lower boundary, being two-dimensional surfaces.

In further consideration, the Lighthouse Paradox is an effect understood with massless particles, photons. We consider that the observance of the expansion of spacetime is also the result of massless particles and propose the theoretical graviton, quantized gravitational energy, would be the candidate quantum constituent of this effect. We would also anticipate the candidate quantum constituent to be effective in propagation over large spacetime intervals, to effectively give rise to the observed spacetime expansion - again, this would be the theoretical graviton.

If we now model gravitons as two-dimensional spherical surfaces, we find a unique non-localized quantum entity. While quantum particles traditionally trace out world lines in Minkowski spacetime, this new spherical model in Minkowski 3D spacetime would trace out a quantized ring on the light cone. This quantized energy would not have a localized spatial bias and this could be viewed as quantized energy that experiences time but not space. Analogous to the photons that experience space but not time, and propagate in every spatial direction in spacetime from an emitting source, we can theorize that this model of the graviton moves in every direction in time from the emitting source. The result would be an expanding and a contracting graviton sphere for each direction in time (positive and negative), and that the quantum creation of these graviton spheres in a pair of expanding and contracting propagation would be entangled. This model not only provides the potential geometrical quantum entities that could give rise to the observance of faster than light spacetime expansion, but also gives a possible model to explain the quantum entanglement entropy at a lower boundary (2S+T) that is being found to potentially give rise to spacetime and its geometry in the higher bulk (3S+T).

VI. Further discussion & considerations

The theoretical model of Eide spheres is unique, but not isolated from other research into quantum gravity. The fundamental principle of quantized, entangled pairs of spherical gravitational energy, in which mass energy information for a 3S+T volume of spacetime could be encoded on a 2S+T boundary (Eide sphere), aligns with what is arguably the foremost leading effort of research into quantum gravity - AdS/CFT correspondence and the holographic principle (and integrated with String Theory), as established and developed by pioneers of theoretical physics, such as Juan Maldacena, Leonard Susskind, Gerard t'Hooft, Edward Witten, Stephen Hawking, and others. AdS/CFT correspondence and the holographic principle describe a 4S+T Anti-de Sitter Universe as being a hologram encoded on an infinitely distant surface in one lower dimension of 3S+T spacetime. Extensive efforts have been made to bring this theory into our familiar 3S+T de Sitter Universe.

A de Sitter Universe could be calculated as having its timelike spatial boundary to be the infinite surface of a sphere, as noted by Leonard Susskind and other leading theoretical physicists on quantum gravity. But what is important to note is that unlike AdS/CFT where the boundary is infinite and infinitely far away, using Eide spheres in a dS/CFT formulation, this infinite and infinitely distant boundary could potentially be replaced with an infinite number of quantized 2S+T boundaries via the entangled pairs of expanding/ contracting Eide spheres - this infinite network of spheres would infinitely saturate all of spacetime. This may help resolve some of the localization challenges of Ads/CFT that have been noted by Maldacena and others.

This view may also be supported by the research of Mark Van Raamsdonk and others where discrete removal of entanglement entropy in a lower boundary was found to discretely remove patches of spacetime in the higher bulk. This may give support to the idea that entangled pairs of Eide spheres could be discretely giving rise to 3S+T spacetime and its respective geometry in the bulk. The notion of an infinitely distant boundary could be replaced with a nearly infinite number of quantized boundaries that could be seen as *quantum projectors* of mass energy information of our Universe.

This might also suggest that this infinite network of quantum boundaries is establishing a quantum error-correcting mechanism that ensures that the physics of the Universe in the 3S+T bulk are stable and coherent, even if there are minor fluctuations in the underlying 2S+T boundary entanglement entropy.

Returning to black holes, pairs of entangled expanding/ contracting Eide spheres, carrying the information encoded of the mass energy of a black hole could potentially help fully resolve the black hole information paradox. As we could possibly have a process where objects fall through the black hole but their information is not completely lost. Given that the entangled pair of Eide spheres move in bidirectional time, this could possibly be seen in the forward time direction as the entangled pair of spheres existing with one sphere inside the black hole and the other outside the black hole. The forward time direction sphere would align with the predicted Hawking radiation and the backward time direction sphere would be allowed to 'escape' the black hole - this entangled quantum energy would fall below the event horizon, but moving in the opposite time direction to the observed black hole, it would

experience the disappearance of the event horizon in the past. This would give this information a route out of the black hole without violating quantum mechanics unitarity or Einstein's General Relativity.

Furthermore, due to the contracting Eide sphere appearing as contracting in the positive time direction due to expanding in the negative time direction. This outside sphere would carry the gravitational energy information of the black hole but in contracting would create a negative pressure in spacetime. Recent studies have explored the possibility that the majority of dark energy of the Universe could come from black holes and this is driving the expansion of the Universe. These contracting spheres from the entangled pairs of Eide spheres could possibly help explain both the black hole information paradox and reveal the source of dark energy that is driving spacetime expansion. As it is known from the Freidmann equations of General Relativity, it's the negative pressure of dark energy that results in Universal spacetime expansion.

There is also the consideration that a reconfiguration of the entanglement entropy of the Eide spheres below the event horizon could explain how information is being stored by the black hole and in essence, not lost. Additionally, the naked singularity of the black hole may possibly be resolved with the presence of these contracting spheres that would create a negative pressure in gravitational energy, possibly preventing the black hole from becoming a true singularity.

It's also noted that while we mathematically identify the event horizon of the black hole, this boundary could possibly be seen as a spherical surface where the cumulative effect of a saturation of spherical surface Eide spheres switches the spatial and temporal roles of the spacetime metric below this boundary - based on our discussion in section III above.

Another theory, which inherently predicts the formulation of Einstein's General Relativity, String Theory has for decades been a leading area of research into quantum gravity, and has had several successful integrations with AdS/CFT and the holographic principle. In String Theory, the experimentally observed particles of the Standard Model of Elementary Particles are represented by one-dimensional open strings. The quantization can be identified along the one-dimensional string. When allowing for states of rotation, the quantization can have existing states that trace out a volumetric probability density sphere. This quantization observance shifts when the model of strings is applied to the quantized gravitational energy particle, the graviton. In String Theory, the graviton holds the unique property of being a closed one-dimensional string, as opposed to being open, like the other elementary particles. The effect of a one-dimensional closed string is that in allowing for states of rotation, the quantization has existing states that trace not a volumetric probability density sphere, but a surface area probability density sphere. When projected into higher dimensions, the gravitational energy of the graviton in String Theory should be expected to be found on the surface of the sphere of quantization, and not the volume of the sphere. The potential alignment of Eide spheres with String Theory may illuminate not only that quantized gravitational energy does propagate as 2S+T spherical surfaces in spacetime, but that String Theory helps to predict this.

A last point of reflection, in considering all the fundamental forces of the Universe - strong, electromagnetic, weak, and gravitational - the force of gravity is extremely weak compared to all other forces. There has been consideration that gravity may appear so weak because it is leaking into other dimensions beyond our observed 3S+T, however, Eide spheres could offer another explanation - the weakness may be the result of quantum gravitational energy being in one less spatial dimension and moving in bidirectional time as opposed to the 3S+T unidirectional time of the other forces. These geometrical spacetime differences could be expected to have force strength differences when all are observed in 3S+T.

While this paper only begins, and in very simplistic frameworks, thought experiments, and discussions, to consider the foundational modeling and potential value of Eide spheres in understanding how quantized gravitational energy could possibly exist in our Universe, there is far more research and potential testing required, including, but not limited to, finding a full Quantum Field Theory for the geometric and mathematical distinctions of Eide spheres.

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