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Conservation of Entropy and Landauer Limit Approach to Gravity in a Relative Holographic Principal Framework

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Abstract
This paper explores how the Landauer Limit at Hawking Temperature input builds a bridge between quantum mechanics and General Relativity. By starting with the energy cost of measurement in constrained degrees of freedom, we uncover insights into gravitational energy and black hole thermodynamics. As the framework develops, it reveals connections to larger questions in physics, including the emergence of dark energy and the role of entropy in cosmic evolution. This step-by-step approach is built on known principles to suggest a unified perspective.

Introduction
Maxwell's Demon has been used to show that the act of measurement has an energy cost. The price Maxwell's Demon must pay to measure entangled-particle spin states can be found by using the Landauer Limit at Hawking Temperature. The use of Hawking Temperature in the Landauer Limit will extract just the energy contained in a constrained degree of spin freedom of a spin ½ particle. The Landauer Limit describes the minimum amount of energy required to erase one quantum bit of information, which is equivalent to the amount of energy constrained within that bit. The Landauer Limit will tell us not only the energy cost of measuring particle spin states, but it will also tell us the amount of gravitational energy and the amount of Hawking radiation energy emitted as a result of measurement. The initial goal is to analyze the relationship between the Landauer Limit using a Hawking Temperature input and the amount of gravitational energy contained within one Planck area of a given black hole's event horizon. We will assume a 1km radius, non-rotating Schwarzschild Black Hole. This will require several steps outlined below to find the relationship.

Steps to Connect Landauer Limit to General Relativity
- Calculate the mass of a 1km black hole using Schwarzschild metric.
- Calculate the total gravitational energy of that black hole in Joules.
- Calculate the number of Planck areas of the given black hole = Np.
- Divide total gravitational energy by the number of Planck areas.
- Calculate the Hawking Temperature, TH of the 1km black hole.
- Use the Hawking Temperature as the input into Landauer Limit formula to convert Kelvin to Joules to find the energy level in the system's constrained degree of freedom.
- Record results and compare the relationship between Landauer Limit and General Relativity by dividing the energy level per Planck area by the energy in Landauer Limit at Hawking Temperature input.

Results Are
General Relativity gravity per Planck area = 1.261×10^{-30}J
Quantum Mechanical calculations from Landauer Limit at $T_H = 1.74 \times 10^{-30}$J.
1.261 divided by 1.74 yields a relationship of 0.724.

A factor of 0.724 indicates an emission process. The Landauer Limit represents a static value. An energy level only has to reach the Landauer Limit for a brief period of time in order to erase a quantum bit. The value of .724 is even closer to 1/ln (4) which indicates a four-bit quantum system.

Calculating 1km Black Hole's Gravitational Energy

Find the mass, M, of a black hole using Schwarzschild MetricCalculate Gravitational Energy $E = MC^2$:

$E = (6.735 \times 10^{29} kg) \times (299{,}792{,}458\ m/s)^2 = E = 6.0736 \times 10^{46}$ J.

Calculate Energy Per Planck Area

$$\frac{6.0736 \times 10^{46} J}{4.813 \times 10^{76}} = 1.261 \times 10^{-30} J$$

Calculate Hawking Temperature of 1km Black Hole

Calculate Hawking Temperature T_H

$$T_H = N/DT_H = \frac{2.8477 \times 10^{-9}\ \text{Joules}\ m^3/s^2}{1.5616 \times 10^{-2}\ \text{Joules}\ m^3/s^2\ \text{per K}} = T_H = 1.823 \times 10^{-7}\ K$$

Calculate Landauer Limit at Hawking Temperature

$E_{Landauer} = K_B T_H \ln(2) = (1.380649 \times 10^{-23} J/K) \times (10823 \times 10^{-7} K) \times 0.6931 = 1.74 \times 10^{-30}$ Joules

Comparison Between Landauer Limit Energy and General Relativity Gravitational Energy

Value from General Relativity per Planck area = 1.261×10^{-30}J
Value from $E_{Landauer} = 1.74 \times 10^{-30}$J

The relationship of 0.724 between GR and Landauer at T_H is quite close to 1/ln (4), a typical emission indicator for a four-bit quantum system. The value of 0.724 indicates that entangledpairs of matter particles contain four bits of quantum information and not merely two, that the cost to perform non-local correlation emits two units of energy.

The Effects of Radius-Based Curvature

Curvature has a significant effect on the level of energy in a constrained degree of freedom. A black hole with a 100km radius has two orders of magnitude greater radius than a 1km black hole and will possess a Landauer Limit value that is two orders of magnitude smaller. 100km Black Hole gravitational energy from GR per Planck area = 1.261×10^{-32}J and $E_{Landauer} = 1.74 \times 10^{-32}$J.

The energy in a constrained degree of freedom, the Landauer Limit, is inversely proportional to a change in radius, which is equivalent to a change in curvature. The energy level defined by the Landauer Limit is not set by the amount of gravity of a local system, but instead by the spatial curvature of that local system. Spatial curvature is defined by an object's radius. Gravity at the surface of Earth will have the same level of energy per emission per entangledpair interaction as a black hole with a 6400km radius. The difference in total gravity between Earth and a black hole the same size of Earth is solely a function of frequency and density of entangled-pair spin measurements. Spatial curvature is the main driver of the price Maxwell's Demon must pay to measure entangled-pairs. This also indicates micro-black holes will emit high energy levels of Hawking Radiation and high levels of gravity per Planck area.

We can now use the 1km black hole Landauer Limit of 1.74×10^{-30}J as a scaling reference and apply the scale of difference in radii in order to calculate the Landauer Limit of a curved system of any radius.

A 1km black hole's Landauer Limit can easily be scaled down to a black hole of 10^{-3} meters.

The Landauer Limit for that smaller black hole can be expressed by- $E_{Landauer} = 1.74 \times 10^{-30}$J multiplied by the scale factor of $10^6 = 1.74 \times 10^{-24}$J.

For a black hole the size of the universe at 13.8BLY, the Landauer Limit energy level can be scaled using the same process. The scale difference between 1km and 13.8BLY is $1.31 \times 10^{23\ \text{orders}}$ of magnitude.

Therefore, we can take the Landauer 1.74×10^{-30} J and divide that by the scale factor of 1.31×10^{23} orders of magnitude difference and find- ELandauer = 1.338×10^{-53}J for a black hole the size of the universe which is equivalent to the energy per Planck area on the cosmic horizon.

We will use this value for the Holographic Relative Cosmic Horizon by treating it as an inverted universe-sized black hole whose event horizon is relative to the observer 13.8BLY away. Now we see that a gravity emission from the cosmic horizon of 1.338×10^{-53}J multiplied by the difference in scale from a 1km black hole is $1.3 \times 10^{23} = 1.74 \times 10^{-30}$J. The cosmic horizon projects the gravity bit amplifying its effect by a change in scale such that local gravity always emerges at the same value determined by local curvature.

Alternative Formula for Calculating the Energy in a Constrained Degree of Freedom, EDoF

We derive an alternative formula for the isolated spin energy, and therefore the gravitational energy per emission event, by considering the energy required to encode information at a given radius. This leads to a natural extension of $E_{Landauer}$ applied to curved spacetime objects shown as E_{DoF}:

$$E_{DoF} = \frac{E_v(r)}{137} \times \frac{\ln(\pi)^2}{\ln(3)} = E_{DoF}1\text{km} = \frac{1.9878\times10^{-28}\text{J}}{137} \times \frac{1.3104}{1.0986} = 1.7301 \times 10^{-30}\text{J}$$

Where:

E_v (r) is the energy in Joules of a photon with a wavelength equal to the object's radius.

137 is the fine structure constant denominator, stripping out charge interactions. ln(π) represents holographic ring encoding, consistent with the information in a circumferential structure of an emitting surface.

$\frac{\ln(\pi)}{\ln(3)}$ represents a triangular folding correction, reflecting how information compresses across energy levels as curvature scales.

This equation provides a radius-dependent model for gravitational emissions, showing that measurement energy in an entangled degree of freedom and therefore gravity, is not a direct function of classical spacetime curvature but rather a result of quantum information encoding on an object's surface. This aligns with the holographic principle, where information is stored on 2D surfaces but manifests as 3D gravitational effects. This also explains why the gravitational energy emitted per entangled-pair interaction on a ≈ 2000 solar mass black hole event horizon with a 6370km radius, approximately 10^{-34}J, is the same level of gravitational energy emitted per entangled pair interaction at the surface of Earth, 10^{-34}J, with Earth ≈ 10^{-6} solar masses. This relationship also suggests that objects in deep space which aren't part of a larger gravitational system may emit according to their local curvature at the higher energies, providing an explanation for dark matter. Objects fill up higher $E_{Landauer}$ energy levels at smaller radii first and fill up lower $E_{Landauer}$ energy levels at larger radii. A 1mm grain on Earth will emit gravitational energy at 10^{-34}J per entangled pair interaction but in the galactic rim far from any other gravitating objects will emit at 10^{-24}J, ten orders of magnitude larger per interaction by not being part of a larger object's system. That grain in the center of Earth would emit gravitational energy per emission of 10^{-24}J. An object position relative to radius in a system affects its gravitational energy level. This explains dark matter. Matter in regions of space where no larger radius system exists must resort to local curvature energy levels.

Definitions: Host Cosmic Horizon, Host Particle, Guest Particle and Entanglement

The following terms need to be identified to fully understand how entanglement causes gravity to emerge.

Host Cosmic Event Horizon

The maximum boundary for any given Host particle consisting of a spherical horizon that behaves much like an inverted universe-sized black hole, relative only to the Host. These cosmic horizons share conceptual similarities with the cosmic horizon model explored in Leonard Susskind and Juan Maldacena's AdS/CFT correspondence and the Holographic Principle.

- Cosmic horizons cause the emergence of dark energy which appears to red-shift objects out of a given Host particle's observable universe.
- Cosmic event horizons are the engines that process information and redistribute entropy from local to cosmic scales.
- Cosmic event horizons are holographic horizons which encode the Host particle's spin as well as all Guest particles' spins.
- Holographic elements of spin from each Guest and the Host are present equally distributed across the cosmic horizon. This means all particles on the cosmic horizon are adjacent to each other.
- Cosmic event horizon act as ledgers for entropy for Guest particles infinitely red-shifting on the Host's cosmic horizon.

Host Particle

A fundamental particle at the center of its own cosmic horizon, which defines the limits of its observable universe.

- A Host particle cannot cross its own horizon, although the horizon size dynamically evolves. -A Host particle has a universe worth of information associated with it,10122 degrees of freedom in the form of Horizon Planck areas, Hawking photons and other Guest particles.

Host Space
The unique relative space between a Host and a Host's cosmic event horizon.

Guest particle
Any particle within a Host particle's observable universe that is not the Host itself.

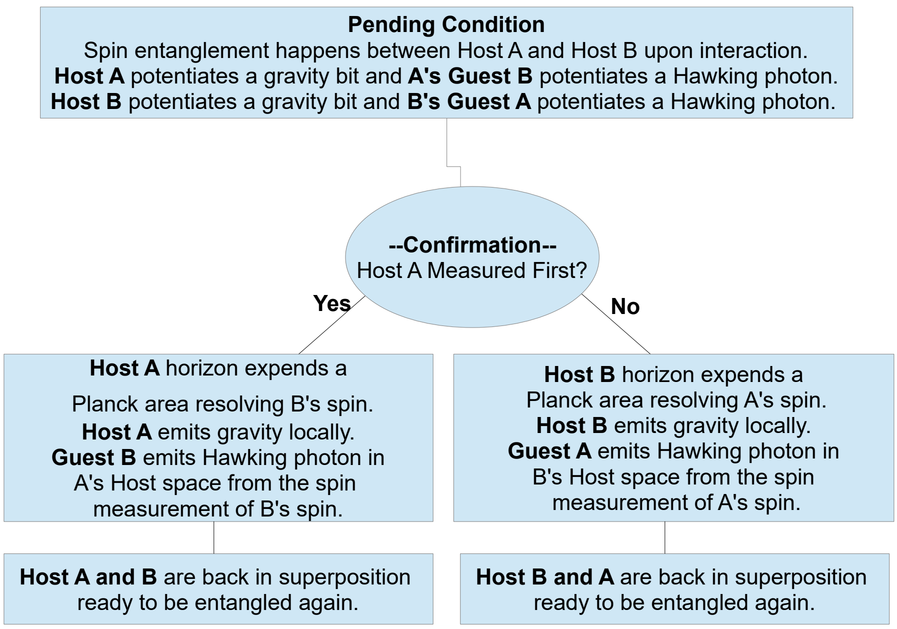
- Guest particles interact dynamically with Host horizons and can appear to exit the Host's universe via cosmic horizon red-shifting.
- Guest particles have 1 degree of freedom.

Entanglement
Occurs when two matter particles in spin superposition interact, establishing a quantum link that forces their spin states into correlated, discrete Up/Down or Down/Up values. Entanglement causes an energy relationship between the Host and the Guest which allows for the instant correlation of spin information, or" Spooky Action at a Distance".

Measuring the Spin of Entangled Pair of Matter Particles
When A and B are both in spin superposition and interact, neither particle has an emergent spin. This creates an energy value in relation to only A's and B's Host horizons which behaves as a bridge between Host A and Host B's cosmic horizon. The entanglement bridge causes a potential for both Host A and Host B's cosmic horizons to load up a virtual gravity bit to be used to correlate A's holographic spin with B's holographic spin. The entanglement bridge also causes a potential for both A's- Guest-B, and B's, Guest-A spin information to load up a Hawking photon. Host A and Host B are waiting to have their spin measured first.

When A is measured, the wave function collapses such that A will use a relative gravity bit from its cosmic horizon to correlate A and B's spin. This breaks the entanglement bridge and Host B and its observable universe have no further interaction in the entanglement spin resolution. The use of a gravity bit from the cosmic horizon causes the cosmic horizon to shrink one Planck area. This action breaks entanglement from the relative gravity bit's reference from A's horizon to only A, gravity emerges locally at A. Then when B is measured, Guest B emits a Hawking photon into A's observable universe from the energy from the entanglement which conserves energy and information.

Pending Condition
Spin entanglement happens between Host A and Host B upon interaction.



Spin Equation
Now we can present the equation for the emission of gravity and Hawking radiation through entangled spin measurement.

$$(S+, E-)_A \rightarrow (S-, E+)_B = 0$$

Where the first Host particle and Host horizon of the pair to be measured is labeled A.

Where S+, - are the emerged spin states of A and B, always opposite, A's state sets Guest B's. Where E- is a local negative energy bit which Nature uses to resolve B's spin uncertainty which shrinks A's cosmic horizon by one Planck area.

Where E+ is Guest B emitting a Hawking photon into A's observable universe expending the energy Guest B stored up as a result of entanglement which also spin locks Host B for the next measurement. This emission from Guest B conserves A's observable universe by adding one bit of positive energy. This accounting conserves energy and information gives us one direction of our universal entropy equation:

$$\Delta S \text{ Cosmic } -1 + \Delta S \text{ Local } +1 = 0.$$

Entropy Reduction, Redistribution of Entropy Versus Reversal of Entropy

Entropy is conserved by redistributing degrees of freedom between local and cosmic scales. Nature does not reverse entropy but instead reduces it through erasure of degrees of freedom. A broken glass is highly unlikely to reform to its prior lower entropy state. Instead of a broken glass, consider a deck of randomly shuffled cards and you are tasked with reducing the entropy in the deck but you aren't allowed to look at any of the cards. To reduce entropy from a deck of cards, simply remove one card from the deck and put it in the discard pile. Now you have 51 degrees of freedom instead of 52 in the card deck, but your discard pile has grown one degree of freedom, so its entropy has increased.

The Connection Between Gravity and Negative Energy

Gravity is a form of negative energy. The negative energy is solely derived the encoding of Guest particles' infinitely red-shifted spin information onto a Host particle's cosmic horizon. Negative energy emerges relationally. The formula to see how the positive energy of particle spin changes sign from red-shifting onto a Host's cosmic horizon is-

$$E_{observable} - E_{initial} = \text{Negative Energy for } \infty \text{ Red-shifted Particle Information}$$

Where $E_{observable} = E_{initial} / (1+Z)$

Where Z is red-shift.

Where $E_{initial}$ is the initial spin energy value for the Guest particle. Spin behaves as a bit, so

we will assign $E_{initial} = 1$.

When $Z = \infty$ then $E_{observable} = 0$.

Now we have 0 – 1 = -1, one unit of negative energy from the reference frame between the Host particle and its cosmic horizon.

The Host cosmic horizon encodes this infinite red-shift event relative to the Host particle as one unit of negative energy which adds one Planck area to the Host particle's cosmic horizon. This accounting conserves energy and information gives us the other direction of our universal entropy equation for the loss of information for one particle locally causes an expansion of the cosmic horizon by 1 Planck area.:

$$\Delta S \text{ Cosmic } +1 + \Delta S \text{ Local } -1 = 0$$

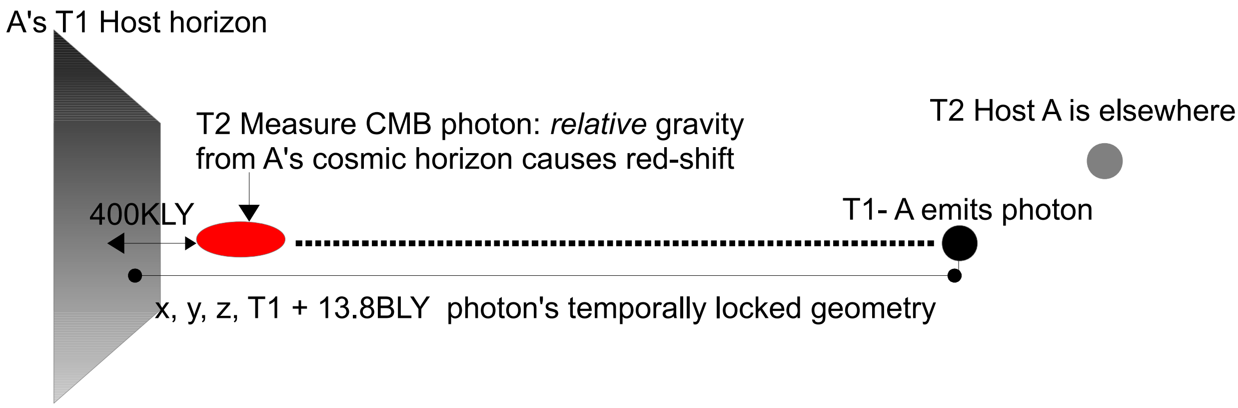
Dark Energy as an Emergent Effect

Dark energy is currently imagined as a force from the vacuum of space by some unseen particle with unknown properties. These mysterious particles are thought to create an expansion force that causes relative event horizons to emerge. Dark energy is better explained arising from relative cosmic horizons as the structure that causes the emergent force of dark energy. Dark energy is inversely proportional to the radius of a Host particle's cosmic horizon. Our current cosmic horizon is about 13.8BLY away. Dark energy is relatively low because the horizon is so distant. When the cosmic horizon becomes smaller over time, due to the resolution of entangled spin measurements and subsequent gravity emissions, the cosmic horizon will appear to have a greater separation effect on objects which are closer. Guest particles are relatively gravitated and subsequently infinitely red-shifted onto a Host's cosmic horizon, causing a loss of local information by one unit, but gaining one Planck area in cosmic horizon. This conservation of entropy operation increases the radius of that Host particle's observable universe by 1/2π Planck lengths. It is important to note that the Host horizons gravitate only relative to the Host particle. The dark energy effect changes the relationship of the Host particle to its most distant Guest particles. This means as we see objects moving closer to our local cosmic event horizon, that distant horizon appears to be the driving force of gravitating those distant objects out of the local observable universe.

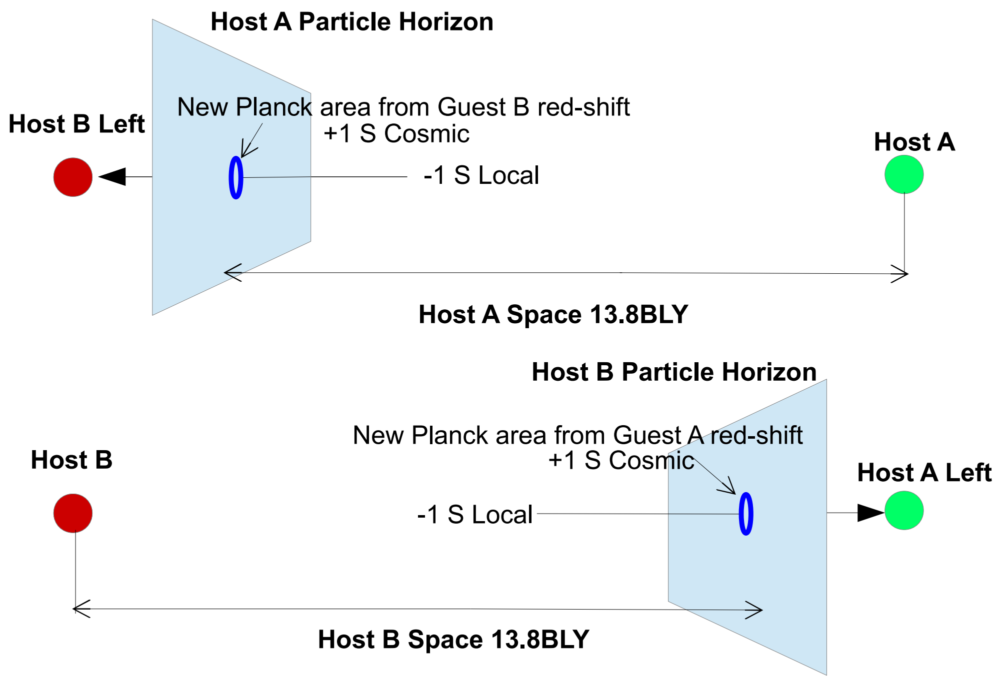
CMB Photon Red-shift and Cosmic Horizons' Gravitation

Photons are emitted from Host particles. When photons are emitted they exhibit a Pending condition in the form of a wave function that contains the photons frequency, emission location and cosmic horizon for that Host particle at that moment in time. Measuring a CMB photon shows us how close to the emitting particle's cosmic horizon the photon traveled before it was detected. When a CMB photon was emitted, it was temporally locked with the emitting particle's cosmic event horizon location of 13.8BLY. Even though the emitting Host particle and its cosmic horizon have moved after emission, the photon red-shifts upon measurement by an amount proportional to its distance to its locked-in coordinate for the Host particle's cosmic horizon. Many believe the universe was only 380,000 LY across when the CMB photon was emitted, but actually we can tell by the CMB photon's red-shift that the universe was already full-sized at 380,000 years old. Light had not had a chance to travel further than 380,000 light years, but the geometry of space was already set to 13.8BLY. Photons travel at C, and therefore cannot evolve or stretch. There is no time for them to evolve. When a photon is measured, we are seeing a temporal snap-shot of a prior state of a particle and its cosmic horizon. The wave function information is the last update a photon received, and the communication is in a Pending status.

Measuring the photon's red-shift, collapses the photon's wave function so the Pending communication is Confirmed which brings the properties into reality. The CMB photon red-shift shows us that even though the light horizon was only 380,000LY, host cosmic horizons were already 13.8BLY away geometrically from the initial 10^{122}. particles created during the Big Bang, produced 10^{122} Planck areas from Guest particles infinitely redshifting on Host cosmic horizons growing those horizons, expanding space giving us today's radius of space.



The Host horizon's sphere of relative gravity bits which behaves relative to the Host particle, much like a distant, inverted black hole event horizon. This causes a red-shift of distant objects relative to the Host particle. Say we are Host A and Host B is being gravitated by our cosmic horizon out of our observable universe. Locally, Host B does not see our 13.8BLY radius cosmic event horizon behaving like an inverted relative black hole event horizon. Instead, Host B sees Host A infinitely red-shifting on B's relative cosmic horizon; being relatively gravitated out of Host B's observable universe at tremendous speed. So, the apparent effect of dark energy is not visible locally but emerges at distance. In this cosmic horizon model, when observer A sees observer B cross the horizon, the same dynamics ensure that observer B simultaneously sees observer A cross, preserving the fundamental symmetry of the horizon's relational encoding.



Gravity as an Algorithm Instead of an Equation

Gravity emerges not as static geometry but as a dynamic computation to resolve spin uncertainty. Gravity in our model begins as red-shifted particle encoding, stored as negative energy on cosmic horizon and manifesting as dark energy. This forms a reservoir of gravity bits that the host can draw from over time to resolve local spin uncertainty when an entangled matter particle interacts with the host. When entangled particle pairs require spin resolution, the cosmic horizon expends a gravity bit from its reservoir to holographically resolve the spins. As the horizon shrinks, it breaks entanglement with the relative gravity bit, causing it to snap back locally as an emission—emerging as gravity as we know it . A Hawking photon is produced upon measurement of B as a receipt for the now smaller observable universe and everything conserves, spin, energy, and even entropy.

Any attempt at creating a fundamental explanation that treats all space as the same will have to normalize Host spaces which will obscure the dynamic fundamental features of nature.

Nature uses an algorithm for gravity instead of a universal equation. The Landauer Limit at Hawking Temperature directly connects quantum mechanics with General Relativity. This is fortunate because instead of having to calculate gravity and dark energy using field equations to describe the dynamics, we can use bits which profoundly simplifies the math. ELandauer represents a quantum logic value of 1, but the actual energy value in Joules depends on the radius of the system.

New Directions for Further Exploration

Proton Horizons and the Strong Force as Gravity

This model suggests that protons are three-quark systems because three is the minimum number of particles required to produce gravity: two entangled particles and an observer particle. Each quark has its own proton-scale horizon, which functions as an analog to color charge.

Within this three-quark system, gravity is emitted at the same energy level as the strong force. The relative gravitational energy per Planck area on the proton horizon causes a local dark energy effect, pulling the other two quarks toward the Host particle's proton horizon. This dynamic interaction naturally explains the strength and confinement of the strong force using gravitational principles rather than a separate fundamental interaction.

One way to see this equivalence between the strong force and gravity is by using EDoF at quark Compton wavelengths, which reveals how gravity at this scale mirrors the binding energy traditionally associated with quantum chromodynamics (QCD).

This model may also explain the deviation in expected proton spin values—traditionally known as the "proton spin crisis." Since there are three interacting quark horizons per proton, the total spin emerges from horizon interactions rather than being a simple sum of discrete quark spins. Also, two quarks are in spin superposition while the other one is a spin-locked observer, meaning only one particle will be able to express spin at a time.

Higgs Boson as a Spin Boson and Entanglement Catalyst

This model further suggests that the Higgs boson functions as a spin boson, providing the necessary energy for entanglement to load up both virtual gravity bits and virtual Hawking photon bits. The Higgs boson energy level is determined by the EDoF of that particular system. The Higgs boson also ensures that matter particles maintain 720-degree spin symmetry, consisting of two opposite, phase-matched 360-degree cycles.

Since entanglement adds energy to the system, it effectively adds a degree of freedom. However, symmetry is broken when the first of the entangled particles is measured, consuming the Higgs boson's energy in the process. This measurement-based energy consumption is crucial for understanding the Higgs mechanism as more than just a massgiving interaction—it directly mediates entanglement-driven gravity formation.

Proton Stability and Quark Confinement as an Entropic Process

This model suggests that the same entropy conservation mechanisms observed on cosmic horizons also operate at the proton horizon level, leading to the remarkable stability of the proton. This could provide a natural explanation for why quarks were confined behind these small proton horizons shortly after the Big Bang and will remain there until the next Big Bang where similar conditions will once again cause quark confinement.

Gravity emission within the proton acts dynamically, with two similarly charged quarks (+2/3) entangling, while the third quark (-1/3) serves as the observer particle that collapses the system's wave function. When the Guest quark emits a Hawking photon, that photon is immediately red-shifted into a neutrino-like state, which is difficult to detect. However, the redshift of this condensed Hawking photon is encoded as additional horizon area on the emitting proton horizon, preserving the balance of entropy.

This journey of discovery began with a question from a friend, Alex Wiederhold, who asked what can be done with the energies in an entangled degree of freedom. What began as an exploration into the Landauer Limit and its connection to gravity we discovered a key that connected quantum mechanics with general relativity. We discovered that energy and information are relative, not absolute. This relativity explains how gravity emerges as an entanglement-driven process, how cosmic horizons encode information, and why gravitational effects appear differently depending on the observer's frame of reference. We have seen how the universe operates as a fully decentralized distributed peer to peer network. Each fundamental Host particle and associated cosmic horizon behaves as its own 10122 quantum bit processor. We discovered how and why cosmic horizons act as ledgers for quantum communication for gravity and dark energy. And lastly, we tied the concept of relatively gravitating cosmic horizons to the red-shift of the CMB photons indicating the early geometry of the universe was already set at 13.8BLY radius relative to the Host particle and its cosmic horizon.

For decades science has wondered why gravity is so much weaker than the other forces. And for the same amount of time, science has brushed off the question of what can be done with the energies in a constrained degree of freedom believing those energies to be irrelevant. Gravity is not an equation, it is an algorithm. And the universe is not a place, it is a process. Space and time emerge in a highly relational and distributed way. Nature conserves entropy, information and energy in the most elegant of ways and that elegance provides the very structure for existence.