

# **The Layered Causality Hypothesis**<sup>v.5.1</sup>

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*A relativistic reframing of dark matter, dark energy, and the age of the universe*

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## **Prologue: A Thought Experiment on Speed and Causality**

### Speed Trap

There are two things every student of relativity learns:

1. There is no preferred frame. All speeds are relative.
2. You can never accelerate to the speed of light, because you would need infinite energy to do so.

Imagine this: there's a planet moving through space at 99.9999% of the speed of light. You want to go there.

A team of scientists builds a powerful accelerator and launches your spaceship to that planet's speed. You arrive. You get out. And when you measure your speed relative to light, guess what? It's still zero. Light still zips away from you at  $c$ . So, you fire up the same kind of accelerator again—and accelerate again to 99.9999% of the speed of light. Same result. You're always standing still in your own frame, and light is always one step ahead.

No matter how many times you repeat the process, from your own point of view, you never get closer to light. Yet from the original scientists' frame, watching you through a telescope, you're slowing down in time and approaching invisibility. Eventually, you pass a threshold. You can't receive light from them anymore. You can't entangle, communicate, or chemically bond. You are causally disconnected, a ghost, still held by gravity, but unreachable by every other force.

This, the Layered Causality Hypothesis suggests, is exactly what has happened to the dark matter we observe. It's not hiding in a shadow realm. It's just on the other side of the speed trap.

# The Layered Causality Hypothesis

## Abstract

*The Layered Causality Hypothesis* proposes that dark matter and dark energy are not distinct substances, but observational effects resulting from relativistic separation across continuous causal frames. When matter crosses a critical threshold—what we call the *Causal Horizon*—it becomes causally disconnected from a given frame for all forces except gravity. This horizon represents the upper boundary of what we later define as the *Jones Window*, a transitional zone of causal degradation. The lower edge of this zone will be called the *Jones Threshold*. This disconnection produces the illusion of invisible mass and accelerated expansion. Redshift, clock rate variation, and the perceived age of the universe are reframed as consequences of frame divergence rather than physical recession. The model introduces no new forces or particles, but instead reinterprets existing observations through the structure of relativistic causality.

## Introduction

It is my intention to tell you a story, told through a combination of narrative, agreed-upon facts, and mathematics. This story offers an alternate view of how the known universe operates. It begins with several interrelated concepts that refer back to one another in such a way that they resist tidy, sequential explanation.

We begin with a mathematical form inspired by the energy-based redshift equations of Drs. Ortiz and Ibarra-Castor (OIC) in their work, *Generalized redshift formula through an energy-based framework*<sup>1</sup>. When we encountered their work, we hoped it could help us derive redshift equations describing a frame-dependent boundary in the fabric of causality, a boundary we call the *Causal Horizon*. The OIC equations did not disappoint. They led us to explore other inversely related quantities, culminating in a simple but powerful equation:  $E \cdot T = h$ . This expression defines the *Causal Horizon Law*, a hard boundary where causal coherence fails due to insufficient energy-time product. It sets the upper bound on any causal frame.

Though it echoes the form of the Heisenberg Uncertainty Principle, this equation expresses a different idea: a fundamental limit on causality across all inertial frames.

From this foundation, we treat the continuum of inertial frames as a kind of fifth dimension of spacetime. To support this view, we introduce a unit of measurement called the *Kirk* ( $\mathbf{Kk}$ ), along with a mathematical framework that integrates it into the existing four-dimensional model. The name “Kirk” was chosen deliberately, without jest, to honor a character who helped ignite our scientific curiosity. (Yes, “Spock” was considered, but it didn’t lend itself as well to metric prefixes.)

With the Jones Window, the Causal Horizon Law, and our fifth-dimensional treatment of inertial frames in place, we explore how redshift can occur without motion through space.

We then consider an historical scenario in which all galaxies were once composed entirely of what we now call dark matter.

We propose a mechanism called *Frame-Drag Braking*, by which galaxies could descend through the continuum of inertial frames until they enter our visible range, becoming the luminous structures that comprise about 20% of the matter in the observable universe. In explaining this process, we introduce the principle of *Mirror Divergence*—a form of symmetry-breaking that leads to a growing offset in time rates between observers. This divergence, we suggest, may help explain the phenomenon now known as dark energy.

We then turn to black holes and the early universe, viewing both through the lens of these ideas, and we conclude by offering predictions and testable consequences that could support or falsify the hypothesis.

Our goal is clarity. We chose a narrative format supported by mathematics to give each idea context and a sense of place within the larger traditional framework. This version of the universe may be unfamiliar, but we believe it is coherent. We invite you to follow the logic of the hypothesis with the same skepticism, curiosity, and love of science that our heroes inspired in us.

## Deriving the Relativistic Interval Principle (RIP)

The Relativistic Interval Principle (RIP) extends the insight that certain physical quantities—when multiplied as conjugate pairs—yield constants that mark coherence thresholds. Unlike the Heisenberg Uncertainty Principle, which limits the precision of measurement, RIP defines the boundary conditions for causal coherence across diverging relativistic frames. At its core, RIP suggests that when the product of conjugate variables falls below a fundamental constant, the capacity for interaction, entanglement, or sustained structure breaks down.

To reinforce these insights from a thermodynamic perspective, we derive RIP through an energy-based framework, extending from the work of Drs. Ortiz and Ibarra-Castor:

*Generalized redshift formula through an energy-based framework<sup>1</sup>*

(Scientific Reports, (2024): <https://doi.org/10.1038/s41598-024-56188-1>).

Their equations, which generalize redshift in terms of energy, allow us to identify how energy loss and time dilation combine to threaten causal coherence across frames.

We begin with four fundamental conjugate relationships that express RIP most clearly:

### Mass × Time

$$m \cdot T = \frac{h}{C^2}$$

Where  $m$  is the mass of the structure,  $T$  is the coherence time in the observer's frame,  $h$  is Planck's constant, and  $C$  is the speed of light in vacuum.

Mass is a form of localized energy, and this expression governs how long a given mass remains coherent within an external frame. When this product falls below

$$T = \frac{h}{mc^2}$$

structures lose the ability to remain causally resolved. This principle underpins coherence loss for massive particles observed across high redshift domains.

### **Momentum × Position**

$$p \cdot x = h^{2,3}$$

Where  $p$  is the momentum of the system,  $x$  is the spatial separation between frames or domains, and  $h$  is Planck's constant.

This expression is well known from quantum mechanics, but RIP reframes it in terms of spatial coherence across frames. As the spatial separation  $x$  between interacting domains increases, momentum coherence degrades. Beyond the coherence limit defined by RIP, structures become spatially unresolved from each other, not just blurry, but (as we will explore) causally unreachable.

### **Angular Momentum × Angle**

$$L \cdot \theta = h$$

Where  $L$  is the angular momentum of the system,  $\theta$  is the angular displacement across frames, and  $h$  is Planck's constant.

Rotational coherence is governed by angular momentum  $L$  and angular displacement  $\theta$ . When

$$\theta = \frac{h}{L}$$

gyroscopic coherence fails. This form of RIP suggests that angular momentum may preserve internal coherence during relativistic descent, acting as a stabilizing quantity even as causal contact with external frames diminishes. In this view, rotational inertia is not merely conserved, it defines the persistence of structure across causally layered domains.

### **Energy × Time**

$$E \cdot T = h$$

Where  $E$  is the energy of the system,  $T$  is the duration (or persistence time) as observed across frames, and  $h$  is Planck's constant.

When the energy  $E$  of a signal or structure is too low relative to the time  $T$  it must persist in a diverging frame, causal coherence breaks down. This boundary provides a universal threshold: when

$$T = \frac{h}{E}$$

interaction fails. In the context of redshift, this product shrinks as time dilation and energy loss both increase, leading to causal disconnection.

These conjugate products form the mathematical backbone of the RIP. One of the most consequential is the Energy  $\times$  Time product, which helps us evaluate how coherence may degrade across relativistic frames. To explore this further, we now examine several specific energy-based forms:

**Thermal Energy:**

$$E_{th} = \frac{3}{2}kT$$

where  $E_{th}$  is the average thermal energy of a system,  $k$  is Boltzmann's constant, and  $T$  is temperature.

**Kinetic Energy:**

$$E_k = \frac{1}{2}mv^2$$

where  $E_k$  is the classical kinetic energy of a mass  $m$  moving at velocity  $v$ , highlighting how relative motion contributes to observable energy.

This classical form highlights that relative velocity between frames reduces the effective kinetic energy observable across domains.

**Photon Energy:**

$$E_{ph} = h\nu$$

Where  $E_{ph}$  is the energy of a photon and  $\nu$  (nu) is its frequency. This form highlights how coherence can degrade when the frequency of photon-based signals redshifts across domains, reducing observable energy across relativistic frames.

### Potential Energy:

$$E_p = mgh$$

Where  $E_p$  is the classical gravitational potential energy of a mass  $m$  at a height  $h$  in a gravitational field of strength  $g$ . While this form is Newtonian, it serves as a simple model for how energy varies with gravitational position—especially relevant in curved spacetimes or accelerating frames where gravitational redshift plays a role.

### Relativistic Energy:

$$E = \gamma mc^2 \quad \text{where} \quad \gamma = \frac{1}{\sqrt{1 - v^2/c^2}}$$

where  $E$  is the relativistic energy of a mass  $m$  traveling at velocity  $v$ ,  $c$  is the speed of light, and  $\gamma$  is the Lorentz factor.

This form reveals that as  $v$  increases, so too does  $\gamma$ , but from the external frame's perspective, observed energy availability drops due to redshift and time dilation.

Though this expression depends on relativistic velocity, we include it here for completeness. Its relevance will become clearer when we introduce frame descent mechanics such as Frame-Drag Braking.

In frame-divergent conditions, energy available for causal interaction diminishes, while the duration  $T$  required for coherent influence grows. These two effects multiply to produce a threshold condition:

$$E \cdot T = h$$

When this product dips below Planck's constant, causal coherence breaks down. In later sections, we will show how this condition defines a fundamental limit on interaction across relativistic frames.

## Energy Conservation Across Causally Disconnected Frames

We now examine a system of two structures that initially share a causal frame. As one descends into a different frame, causal disconnection occurs, leaving the other behind.

To explore this process more rigorously, we return to the Relativistic Interval Principle (RIP), this time deriving it from two complementary perspectives:

1. The classical conservation of energy and momentum, and
2. The energy-based redshift formalism developed by Drs. Ortiz and Ibarra-Castor.

These derivations confirm that causal disconnection is not a breakdown of conservation laws, but a redistribution of conserved quantities across divergent inertial frames.

## Derivation from First Principles

We begin with the standard relativistic energy-momentum relation:

$$E^2 = (pc)^2 + (m_0c^2)^2$$

Where  $E$  is the total energy of an object or system,  $p$  is its momentum,  $c$  is the speed of light, and  $m_0$  is its rest mass.

In a rotating system with relative motion across frames, energy naturally separates into two components:

- $E_{\text{rot}}$ : the rotational or internal energy
- $E_{\text{rel}}$ : the relativistic energy associated with motion relative to the observer

Assuming the system's total energy remains conserved:

$$E^2_{\text{total}} = E^2_{\text{rot}} + E^2_{\text{rel}}$$

This expression defines the Relative Interval Principle: a system's total energetic identity is preserved through internal redistribution, even as causal disconnection occurs. Energy does not vanish, it shifts form within a conserved structure.

## Derivation via Ortiz-Ibarra-Castor Redshift Formalism

Ortiz and Ibarra-Castor present a generalized framework for redshift based on intrinsic energy differences rather than spatial motion. Their formulation begins with the quantum energy relation:

$$E = hf$$

A change in observed frequency implies a change in measurable energy:

$$z = \frac{(f_f - f_o)}{f_o}$$

Again, where  $f_f$  is the frequency in the frame where the signal was emitted,  $f_o$  is the frequency measured by the observer and  $z$  is the observed redshift.

In this framework, the observed redshift is not due to recession but to a redistribution of energy from one component to another. If internal spin decreases ( $E^2_{\text{rot}}$  goes down), the relative motion component must increase ( $E^2_{\text{rel}}$  goes up), or vice versa, preserving:

$$E^2_{\text{total}} = E^2_{\text{rot}} + E^2_{\text{rel}}$$

Thus, RIP is recoverable from both classical conservation and quantum-energy-based redshift. In both views, redshift is a reflection of internal structural rebalancing, not necessarily motion.

The basic form of the Relative Interval Principle (RIP) has now been derived from both classical and energy-based formulations. However, its full implications reach beyond any single system. What follows is a generalized version of RIP, showing how this principle can apply not only to total energy, but to a wide range of conserved quantities across causal frames.

## Relative Interval Principle (RIP): Generalized Form

Based on the energy-based redshift formulation introduced by Ortiz & Ibarra-Castor (2024), RIP reinterprets redshift not as a loss of energy, but as a redistribution of conserved quantities into an inaccessible causal domain.

Where standard energy equations account only for observable quantities within a single inertial frame, RIP posits that the total energy and momentum of a system remains conserved via interval-like structures, even when part of that system becomes causally displaced. These quantities are expressed in a squared-sum form analogous to the spacetime interval:

- **Total Energy:**  $E^2_{\text{total}} = E^2_{\text{rot}} + E^2_{\text{rel}} \rightarrow$
- **Momentum:**  $p^2_{\text{total}} = p^2_{\text{local}} + p^2_{\text{rel}}$
- **Ang. Mom.:**  $L^2_{\text{total}} = L^2_{\text{orbit}} + L^2_{\text{rel}}$
- **Kinetic:**  $E^2_{\text{kin}} = E^2_{\text{linear}} + E^2_{\text{rel}}$
- **Thermal:**  $E^2_{\text{thermal}} = E^2_{\text{temp}} + E^2_{\text{rel}}$
- **Photon:**  $E^2_{\text{photon}} = E^2_{\text{freq}} + E^2_{\text{rel}}$
- **Potential:**  $E^2_{\text{pot}} = E^2_{\text{field}} + E^2_{\text{rel}}$

This framework preserves conservation laws even as systems become causally displaced. It explains why redshifted systems may appear to lose energy, spin, or coherence while still retaining a conserved total. It also reinforces the idea that what seems like energy loss is in fact a geometric redistribution of structure across relativistic frames.

The coherence of this redistribution, however, is not infinite. As the energy of a structure drops and the duration over which it must persist increases, their product can fall below a universal threshold.

We refer to this boundary as **the Causal Horizon Law**: a definitive cutoff beyond which meaningful interaction fails. The signal continues normally, but nothing on the receiving end can make coherent sense of it.

## The Causal Horizon Law and Gravitational Coherence

We have proposed the Causal Horizon Law as an invariant relationship between energy and time across relativistically separated frames:

$$E \cdot T = h$$

Where  $E$  is the total energy exchanged within a shared causal frame,  $T$  is the shared proper-time interval over which this exchange remains coherent, and  $h$  is Planck's constant.

This limit marks the point at which meaningful interaction through electromagnetic or quantum forces becomes impossible. Beyond this boundary, systems can no longer remain coupled through conventional field interactions.

The Causal Limit is now defined quantitatively as the point at which:

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} = 707 \Rightarrow v \approx 0.99999999999989 c$$

Therefore, causal disconnection occurs when the relativistic time dilation factor  $\gamma$  between frames reaches 707, defining the boundary of the Causal Horizon.

Since we are talking about relativity, it is important to re-emphasize that despite its seeming proximity to the speed of light, it is actually no closer to the speed of light than the reader is right now. We refer to this limit as a 'horizon', precisely because it is a limit that moves with the observer. In this continuum, we are never truly closer to the speed of light, therefore the apparent closeness to  $c$  is not relevant.

Although no object experiences time change locally, extreme relativistic separation between frames leads to phase mismatch too great for coherent field interaction

Gravitational effects, however, appear to persist. Unlike other forces, gravity arises from spacetime geometry and may continue to link systems long after other forms of coherence have failed. We refer to this persistence as Gravitational coherence: the continued gravitational relationship between structures that are no longer causally connected by quantum or electromagnetic means.

### Significance

This relationship offers a coherent explanation for how dark matter structures can continue to gravitationally influence galaxies after causal disconnection. It bridges concepts from general relativity and quantum mechanics without requiring new particles, fields, or forces.

**The Causal Horizon Law** is proposed as a foundational structural constraint for any framework seeking to unify gravity with quantum behavior through frame-based analysis.

As a relativistic boundary, the Causal Horizon occurs when time in a relativistically separated frame dilates to such an extent that causal coherence is no longer sustainable. At this boundary, proper time has slowed to 1/707th of the observer's local rate, or vice versa.

## Causal Disconnection and the Jones Window

Since we have now established that the product of energy and time defines a causal envelope: a limit beyond which coherent interaction between systems breaks down. This disconnection is not simply a matter of spatial distance or relative velocity; it reflects a deeper incompatibility between energy–time structures across relativistic frames.

To describe the onset of causal disconnection within an observer's frame, we introduce **the Jones Threshold**: a frame-relative boundary at which the spectral signature of even the simplest atom—hydrogen—redshifts so far that it no longer registers coherently in a lower-energy frame. From the perspective of the observer, all quantum and electromagnetic markers of the causally distant system vanish into noise. Causal interaction becomes impossible. The system isn't gone in any absolute sense; it simply no longer lives in a causally accessible domain

The Jones Threshold does not represent a hard causal wall, as the Causal Horizon does. Rather, it marks the beginning of a fuzzy transition zone where quantum coherence fades, entanglement fails, and electromagnetic interactions redshift out of range. Further, it defines the lower edge of a broader transitional region we call **the Jones Window**, a window which ends at the Causal Horizon, where causal interaction fails completely. What remains is only gravity, operating across frames through geometric continuity.

## Redshift as Frame Descent

In traditional cosmology, redshift is interpreted as the Doppler-like effect of galaxies speeding away through expanding space. But in a frame-relative model, redshift need not imply motion through space at all. Instead, redshift may signal a divergence of inertial frames; stretching of the energy–time fabric between observer and source.

This view finds support in the work of Ortiz and Ibarra-Castor (once again), whose generalized redshift equations describe spectral loss via energy differentials across reference frames. In their formulation, frequency, and therefore energy, is observed to change even without motion, so long as the observer and emitter occupy distinct relativistic domains.

As systems descend into lower-energy frames, the coherence time  $T$  stretches, while the observable energy  $E$  diminishes. The product  $E \cdot T$  approaches the Causal Horizon,  $h$ , and all interactive capacity begins to fail.

This is redshift without motion. The structure *has not* fled through space, it has simply *fallen*, causally out of range.

## Electromagnetic Redshift and Causal Disconnection

One of the earliest and clearest signs of causal disconnection across relativistic thresholds is the redshifting of electromagnetic signals. As objects move at high velocities relative to an observer, the photons they emit become increasingly redshifted. As we will see, this effect is not merely a Doppler phenomenon; it reflects a deeper causal divergence wherein electromagnetic communication itself becomes unsustainable.

### Classical Doppler Redshift

In special relativity, the relativistic Doppler shift for light emitted at velocity  $v$  is given by<sup>[4]</sup>:

$$z = \sqrt{\frac{1 + \frac{v}{c}}{1 - \frac{v}{c}}} - 1$$

This formulation assumes a continuous observational connection between source and observer. However, it breaks down conceptually when the source crosses a velocity threshold at which its signals are no longer observable in any practical or meaningful way.

### The Causal Horizon and Frame Disconnection

As velocity increases, redshift grows without bound. At extreme values (such as  $z \approx 0.58$  for hydrogen's spectral lines), the emitted light becomes undetectable in the observer's frame. This is, a result of relativistic disconnection between causal frames, (rather than distance or obstruction). Importantly, the signal itself continues unchanged; it may still be received by any observer within its own causal range. However, for frames beyond a critical relativistic separation, the conditions required for electromagnetic interaction (including phase and frequency coherence) can no longer be maintained. At this point, signal transmission fails, functionally, and physically.

To see this more formally, consider the phase of an electromagnetic wave:

$$\varphi = kx - \omega t$$

Where:  $\varphi$  is the wave phase,  $k$  is the wave number (in radians per unit length),  $x$  is position,  $\omega$  is angular frequency (in radians per second), and  $t$  is time.

For constructive interference to occur (which is necessary for detection and coherence), the phase difference between emitter and observer must remain bounded:

$$\Delta\varphi = |\varphi_{emitter} - \varphi_{observer}| < constant$$

At relativistic separations (time and spatial coordinates diverge such that  $\Delta\phi \rightarrow \infty$ ). This renders phase alignment impossible, and no meaningful electromagnetic coupling can occur. Thus, signal reception fails as a direct physical consequence of frame divergence.

This breakdown can also be understood in terms of energy-based redshift. Using the generalized formulation from Ortiz and Ibarra-Castor<sup>[1]</sup>:

$$E = \frac{(h^2 f^2)}{(2p^2)}$$

Where  $E$  is the specific energy,  $h$  is Planck's constant,  $f$  is frequency, and  $p$  is momentum.

we observe that as frequency  $f$  decreases due to redshift, the observable energy  $E$  drops proportionally to the square of the frequency. This means even modest reductions in  $f$  lead to rapid energy loss; if frequency is halved, energy falls to one-quarter. This relationship shows that redshift leads to a real and irreversible energy loss, not recoverable by shifting observational frame alone. Thus, causal disconnection is not merely observational; it reflects a breakdown in electromagnetic exchange that cannot be resolved by changing reference frame alone.

## The Jones Threshold and EM Signal Breakdown

Mathematically, the Jones Threshold marks a transition zone where electromagnetic interaction begins to fail due to frame separation. This electromagnetic failure can be interpreted as a quantum limit on coherence. As two systems become increasingly separated in energy and time, they approach a condition where the interaction itself cannot physically occur.

Formally, this is captured by the Causal Horizon Law:

$$E_{\text{rel}} \cdot T_{\text{rel}} \leq h \text{ [5]}$$

Where  $E_{\text{rel}}$  represents the energy of the external object (or signal) as perceived from the local frame,  $T_{\text{rel}}$  represents the duration over which coherent interaction might occur, and  $h$  is Planck's constant.

This relationship sets the minimum product of relative energy and time necessary for a causal event to occur. If this product falls below Planck's constant, no exchange of photons, or any quantum force carriers, is possible. When the product of these falls below Planck's constant, no exchange of photons, or any quantum force carriers, is possible. The interaction channel collapses as a direct result of quantum limits on energy–time coherence. This law was derived in the RIP section as a natural limit imposed by the conjugate nature of energy and time.

From this perspective, the Jones Threshold does not mark the absolute limit, but rather, the beginning of a relativistic drift (through the *Jones Window*) into incoherence. Beyond this point, electromagnetic, strong, and weak interactions fail.

*However, gravity remains.*

As described above, gravitational influence persists through and past the Jones Window because it does not require particle exchange. Instead, gravity is the curvature of spacetime itself, and this curvature can still shape the motion of distant objects even when no other form of interaction survives. Thus, the Jones Window represents a gradual boundary in quantum connectivity, not in geometric influence.

## Coherence Breakdown Across the Jones Threshold

Causal disconnection beyond the Jones Threshold leads to the breakdown of quantum coherence. This conclusion can be reached through multiple independent formalisms, each reinforcing the same physical consequence: systems that are causally disconnected cannot maintain entanglement or phase coherence across frames.

### Phase Decoherence Due to Relativistic Drift

Consider two initially entangled quantum systems sharing a synchronized phase evolution. Each system has a wavefunction of the form

$$\psi(x, t) = A e^{i(kx - \omega t)}$$

where  $\psi(x, t)$  is the wavefunction describing the phase-coherent evolution of a quantum system,  $A$  is the normalization constant,  $e$  is Euler's number,  $i$  is the imaginary unit,  $k$  is the wave number,  $x$  is position,  $\omega$  is angular frequency, and  $t$  is time.

As one system accelerates to relativistic speed (e.g., beyond  $0.8c$  relative to the other), the coordinate time  $t$  in its frame dilates substantially. The resulting desynchronization in the phase factor  $(kx - \omega t)$  causes the systems' relative phase to drift. Over time, the phase difference  $\Delta\phi$  grows unbounded, eliminating the conditions required for coherent interference. Thus, phase-based coherence is lost as the systems diverge across relativistic domains.

### Entanglement Collapse Through Partial Trace

Suppose two particles are in the maximally entangled Bell state:

$$|\Psi\rangle = \left(\frac{1}{\sqrt{2}}\right)|0\rangle_A |1\rangle_B + |1\rangle_A |0\rangle_B$$

where  $|\Psi\rangle$  is the entangled two-particle state,  $|0\rangle$  and  $|1\rangle$  are the basis states, and the subscripts  $A$  and  $B$  label the two entangled particles (or systems) associated with observers  $A$  and  $B$ , respectively.

If particle  $B$  accelerates across the Jones Window, it becomes causally inaccessible. To describe the remaining system, one must trace over  $B$ 's degrees of freedom:

$$\rho_A = Tr_B(|\Psi\rangle\langle\Psi|) = \left(\frac{1}{2}\right)(|0\rangle\langle 0| + |1\rangle\langle 1|)$$

Where  $\rho_A$  is the reduced density matrix of subsystem A,  $Tr_B$  denotes the partial trace over subsystem B,  $|\Psi\rangle\langle\Psi|$  represents the outer product of the entangled state with itself, forming the full density matrix,  $|0\rangle\langle 0|$  and  $|1\rangle\langle 1|$  are projection operators onto basis states of subsystem A, and  $\frac{1}{2}$  is a normalization constant ensuring total probability equals 1.

This reduced density matrix is a classical mixture, not a quantum superposition. The act of tracing over the inaccessible system results in decoherence, mathematically ending entanglement from the perspective of the accessible observer.

### Breakdown of Simultaneity and Frame Agreement

Additionally, coherence can be lost through relativistic failure of simultaneity. At sufficient frame separation, different observers no longer agree on the order or timing of quantum events. This destroys the unitary evolution required for shared state descriptions in entangled systems. While this mechanism is more conceptual than algebraic, it supports the same conclusion: causal disconnection implies the end of non-gravitational coherence.

Concluding this section, we emphasize that the Jones Threshold is not a boundary of matter or motion, but of meaning: it defines the outer edge of coherent quantum interaction.

## Redshift Without Motion

This section explores how redshift and time dilation can arise purely from energy differentials between frames, as opposed to classical motion. Using an energy-based formulation inspired by the work of Ortiz and Ibarra-Castor, we describe how frequency and time shift as a function of frame separation.

We begin with the OIC redshift equation:

$$z = \frac{(E_e - E_o)}{E_o}$$

Where  $z$  is the redshift measured from the observers frame,  $E_e$  is the energy of the emitted signal, and  $E_o$  is the observed energy.

Since photon energy is related to frequency by  $E = hf$ . We can substitute and express redshift as:

$$z = \frac{(f_f - f_o)}{f_o}$$

Where  $f_f$  is the frequency in the frame where the signal was emitted, and  $f_o$  is the frequency measured by the observer.

Solving for  $f_f$ :

$$f_f = f_o(1 + z)$$

Now, if we assume a similar transformation applies to time we can relate proper time in the emitting frame ( $T_s$ ) to the observer's time ( $T$ ):

$$T_s = \frac{T}{(1 + z)}$$

Where  $T_s$  is the proper time in the shifted frame,  $T$  is the proper time measured in the observer's frame, and  $z$  is the observed redshift.

This tells us that, even without classical motion, a redshift implies slower time passage in the source frame relative to the observer. The redshift is not due to velocity, but to an energetic separation in causal structure.

To relate this to frame-relative momentum, we define a dimensionless momentum ratio  $M$  representing velocity relative to the Jones Threshold ( $\frac{v^2}{c^2}$  normalized to  $0.8c$ )

$$T = \sqrt{1 - M}$$

Where  $T$  is the observed time rate, and  $M$  is the fractional motion  $\frac{v^2}{c^2}$  between frames.

Then:

$$\frac{T_s}{T} = \frac{1}{1 + z} = \sqrt{1 - M}$$

This expression ties redshift, time dilation, and momentum into one unified relationship. It shows that, from the perspective of one frame, the other appears time-dilated and its signals appear redshifted, even when neither frame is undergoing classical motion relative to the other.

This energy-based approach provides a critical foundation for understanding mirror divergence and Frame-Drag-Braking, where systems appear to drift apart causally without ever accelerating through space.

## Gravity and the Causal Reach of Dark Matter

We propose that what is commonly referred to as dark matter is not an exotic substance, but ordinary matter that exists in a higher causal range than our own. This frame separation is not merely spatial or temporal, but structural, defined by the breakdown of causal interaction across what we call the Jones Window, and culminating at the Causal Horizon.

We further propose that gravity is distinct among the fundamental interactions in that it does not require direct quantum or electromagnetic coherence. Instead, it emerges from the geometric curvature of spacetime itself, and may remain causally effective even when all other forces fail. This property makes gravity uniquely capable of interacting across causally disconnected frames.

The recent formulation of the Causal Horizon Law, which asserts that the product of energy and time remains invariant across relativistically separated frames ( $E \cdot T = h$ ), helps to mathematically explain this persistence. While quantum and electromagnetic interactions rely on phase coherence, gravity relies on this deeper invariance.

Observational evidence aligns with this idea. We detect strong gravitational effects, such as anomalous galactic rotation curves, gravitational lensing, and cosmic structure formation, that suggest the presence of mass we cannot otherwise detect. *This is precisely what we would expect* if matter exists beyond the Causal Horizon—causally disconnected in every respect but still gravitationally linked through  $E \cdot T$  invariance.

Gravitational waves also support this perspective. Their massless propagation at  $c$  and geometric origin suggest that gravitational interaction need not be mediated by localized particles. It is continuous, even in the absence of direct signal exchange, providing a mechanism for the inter-frame gravitational influence that defines gravitational coherence.

In this model, the “dark matter” component of the cosmos may consist of structures residing in higher causal frames. From our perspective, they appear redshifted beyond quantum and electromagnetic interaction due to relativistic divergence, rather than spatial recession. Their separation reflects a difference in causal range rather than physical distance or motion through space.

From a thermodynamic standpoint, causal descent is far more probable than ascent. A structure entering a lower causal frame must lose relativistic energy, an outcome fully consistent with the second law of thermodynamics,<sup>2</sup> which favors entropy increase through energy dissipation. By contrast, causal ascension would require an unexplained energy input to move structures upward across the Causal Horizon. Conservation of energy also favors descent, as it involves a reduction in velocity and energy rather than a mysterious gain. Therefore, it is far more plausible that visible matter descended from a dark matter frame than that dark matter ascended from ours. This thermodynamic flow suggests that visible structures like galaxies and stars are remnants of systems that once occupied higher causal frames.

Accordingly, dark matter may be the result of structural coherence preserved by the Causal Horizon Law. It arises naturally from the combination of relativistic geometry, causal separation, and energy–time invariance, without requiring any new particles or unknown fields.

## **The Twin Paradox: The Quiet Second Paradox**

In traditional discussions of the twin paradox, one twin remains on Earth while the other departs in a high-speed rocket. Upon return, the traveling twin is found to have aged less than their stationary sibling. This classic relativistic scenario is resolved by recognizing that the traveling twin underwent acceleration—an asymmetry that distinguishes the two frames.

But there is a subtler, often unspoken paradox buried in the return leg: once the rocket reaches its destination and ceases acceleration, it has achieved a new inertial frame; a new baseline frame of reference. Any subsequent firing of the rockets, regardless of direction, initiates further acceleration away from that frame. Space, having no preferred direction nor absolute memory of origin, treats any change in velocity, even one aimed at returning, as a new deviation. There is no

recovery of the original state; inertial drift is irreversible by the simple firing of rockets, even when labeled retrorockets intended to reverse course.

This quiet second paradox—the irreversible departure from a higher frame — is a conundrum: there is no natural way back through acceleration. The only mechanisms that seem to enforce frame alignment are collision and gravitational capture. These events forcibly realign proper times by collapsing disparate frames into one—a process not unlike the gravitationally induced collapse of superpositions, proposed by Sir Roger Penrose<sup>8</sup>.

Penrose’s model proposes that when mass distributions differ between quantum states, gravity eventually forces a collapse into a single geometry. His governing expression,  $\mathbf{E}_G \cdot \boldsymbol{\tau} = \hbar$ , bears a striking resemblance to our own Causal Horizon Law:  $\mathbf{E} \cdot \mathbf{T} = \mathbf{h}$ . Though Penrose speaks of quantum geometries and we speak of causal frames, both models point toward a fundamental instability when systems attempt to straddle incompatible states.

This resonance with Penrose and Hameroff’s work<sup>9</sup> suggests a deeper commonality: whether discussing conscious collapse or inertial descent, the universe (or, at least, gravity) seems to resist sustained multiplicity of frames. Collapse, whether quantum or relativistic, emerges as gravity’s mechanism for restoring coherence across divergent frames.

## Navigating Inertial Frames as a Fifth Dimension

While contemplating the next section on Frame Drag Braking, we found that the language involved in traversing inertial frames, without spatial motion, quickly becomes conceptually misleading. The idea that a galaxy might “descend” into a new frame, yet remain motionless in space, presents a taxing linguistic challenge. To address this, we adopted a metaphor that treats movement through inertial frames as though it occurs along a *fifth dimension* of spacetime.

Whether inertial frames truly correspond to a fifth spatial dimension is not our argument here. What matters is that this metaphor provides a useful coordinate system, one that allows us to describe changes in causal position using familiar geometric language.

Just as we do not directly *see* space or time but instead observe change and separation through them, we never directly *see* inertial frames. We observe their effects: time dilation, redshift, coherence breakdown, and gravitational asymmetries.

These reflections led us to define a scalar quantity, **the Kirk metric**, which represents a system’s causal position within the continuum of inertial frames. A higher Kirk value corresponds to a frame with a slower time rate relative to the local observer; a lower Kirk value corresponds to a frame with faster ticking clocks. In this view, a descending galaxy does not accelerate in space, but instead moves *through the Kirk scale*, shifting to a frame where time runs faster.

This model offers a clean way to describe what happens during frame drag braking, discussed in the next section. Instead of tracking velocity vectors through space, we track shifts along the

Kirk dimension, allowing us to speak meaningfully about gravitational descent, redshift, and causal disconnection as if they were forms of motion through this hidden axis of reality.

## How the Kirk scale works

To help describe motion through inertial frames, without requiring spatial displacement, we introduce a new unit of measure: **the Kirk**, symbolized as  $K_k$ . The Kirk is a scalar quantity that represents an object's causal position within the continuum of relativistic frames. Unlike a physical location, the Kirk index tells us *how far* a system is from the observer's inertial frame in terms of time rate and energy coherence.

We define:

0.0  $K_k$  as the observer's own frame (full causal coherence) and,

$\pm 1.0 K_k$  as the *Causal Horizon* — where  $E \cdot T = h$ , and causal interaction breaks down entirely.

The scale provides a bounded metric for describing this "fifth dimension", a measure of causal separation.

As a system descends gravitationally (as we will see in Frame Drag Braking), its position on the Kirk scale decreases. As a system accelerates away, it climbs the Kirk scale. This allows us to distinguish co-located systems that are causally separated by time dilation or energy imbalance.

Kirk coordinates do not measure total elapsed time (proper time), but rather time rate — how quickly time flows in that frame relative to an external observer. This means a system can sit still in space yet still *move* through Kirk space by gaining or losing relativistic energy.

### Metric Subdivisions:

- 1 millikirk (m $K_k$ ) = 0.001  $K_k$
- 1 centikirk (c $K_k$ ) = 0.01  $K_k$
- 1 decikirk (d $K_k$ ) = 0.1  $K_k$ , and so on.

### Example values:

- Earth vs GPS satellite:  $\sim 0.003 K_k$
- Outer galactic arms vs core:  $\sim 0.09 K_k$
- High-redshift galaxies near causal cutoff:  $\sim 0.97 K_k$

This framework provides a tool for describing frame-relative motion, time dilation, and disconnection (See Fig. 2.), and will now allow us to more clearly express what happens during Frame Drag Braking.

Just as velocity is defined as  $dx/dt$  in the Lorentz system, we define the **Frame Traversal Rate** as  $dK/dt$ , the rate at which a system moves through inertial frames, measured in Kirk units per unit of local time.

# Frame Drag Braking and the Descent from Dark Matter

## Origins and Motivation for Frame Drag Braking

The concept of Frame Drag Braking arose from a paradox: If dark matter exists in a faster relativistic frame, how can a slower-moving galaxy be gravitationally bound to it? This led to the realization that perhaps dark matter and galaxies did not encounter each other later, but instead formed together, initially sharing the same inertial frame. The question then became: what mechanism could have driven the divergence of those frames? Angular momentum alone could not produce redshift. We considered frame-dragging as a potential cause but soon realized that a galaxy's attempt to rotate the surrounding spacetime, might be resisted by the massive, symmetrical presence of surrounding dark matter. This resistance, we proposed, forces the system into relativistic descent. In this model, frame-drag braking is not the only possible path of inertial descent, but it is a viable one—and perhaps the only known mechanism that can move a system *downward* through Kirk coordinates, in contrast to the upward drift caused by conventional acceleration. While the Twin Paradox ends in eventual frame realignment, its acceleration phases only drive further separation. Frame-drag braking, by contrast, may initiate frame convergence under resistance. Still, gravitational containment on all sides is not equivalent to collision or orbital capture, and whether it truly collapses frames remains open to interpretation.

The idea that gravitational capture may unify divergent frames, or that Penrose's gravity-induced collapse echos the **Causal Horizon Law** ( $\mathbf{E} \cdot \mathbf{T} = \mathbf{h}$ ), suggests that descent via Frame Drag Braking may represent a missing piece in our understanding of both relativistic and quantum frame alignment.

## The Story of Descent

In the Layered Causality framework, we begin not with a visible galaxy, but with a galaxy composed of what we now call dark matter. From its own frame, this system is coherent, gravitationally bound, and causally intact. But to an observer in a slower inertial frame, such as our own, it is invisible. Its photons are redshifted beyond the range of electromagnetic coherence. Its causal separation places it beyond the **Jones Threshold**, outside the **Jones Window**, and past the **Causal Horizon**.

This “dark galaxy” occupies a higher Kirk coordinate within the relativistic causal landscape. Because it is gravitationally bound to a larger structure, it can rotate but cannot freely move away, much like Earth cannot freely escape the Sun. Surrounded symmetrically by dark matter, the galaxy has no preferred axis for spatial escape. But it can lose relativistic energy.

Over time, the system's angular momentum interacts with the geometry of its surrounding domain. The surrounding dark matter structure imposes a frame-dragging resistance that prevents classical spacetime deformation. Spacetime cannot be meaningfully dragged when there is no

asymmetry to deform against. This resistance results in energy redistribution: the galaxy is unable to lose energy through classical rotation or spatial motion and instead descends inertially.

This process is known as **Frame Drag Braking**. The galaxy's attempt to impose rotation on its surroundings is met with a relativistic counterforce that slows its angular momentum. This sets off a feedback loop:

1. A slight loss of relativistic energy increases the galaxy's clock rate.
2. From the slower dark matter frame, this appears as increased rotation.
3. This increased frame drag attempts to deform spacetime.
4. The surrounding dark matter resists this, forcing further relativistic energy loss.

This loop intensifies the descent. As relativistic energy increases and angular momentum decreases, the system moves downward in Kirk coordinates. Its frame accelerates in time relative to the surrounding dark matter. While the galaxy becomes brighter and more coherent to our frame, it remains gravitationally bound to the invisible structure above it.

We express this process with a simplified formulation:

$$\frac{dK_k}{dt} \propto -\frac{\tau}{L}$$

Where:  $K_k$  is the Kirk coordinate (causal frame position),  $\tau$  is the torque from frame-drag resistance, and  $L$  is the system's angular momentum.

As the system descends from, say,  $K_k = 0.97$  (barely visible) to  $K_k = 8.2$  (entering the Jones Window), more of its emissions fall within our coherent range. The galaxy becomes visible. But we do not see the larger dark structure from which it emerged; it remains beyond our Causal Horizon.

This descent is unidirectional. The galaxy does not coast to a stop in a new frame; it is caught in a gravitational potential, constantly falling. Because gravitational interaction persists even after other forces have disconnected, the system continues to descend. It is conceivable that it would eventually descend past the range of visibility in the opposite direction.

This is Infinite Descent: a slow, gravitationally governed spiral through relativistic frames, where each step downward in Kirk position results in faster proper time and greater causal interaction with lower-energy frames.

The Kirk scale lets us track this descent quantitatively. Each drop in  $K_k$  reflects a gain in clock speed and a shift toward causal interaction with slower frames. This provides a natural

explanation for the emergence of visible galaxies from within dark matter: they are the cooled embers of once-higher-frame systems, gravitationally dragged down into our view.

The conservation of energy across disconnected frames can be preserved using a reformulated version of the Ortiz-Ibarra-Castor (OIC) redshift equation. In this view, the original energy of the system is redistributed orthogonally between rotational kinetic energy and relativistic descent energy, preserving total energy across the disconnection boundary:

As  $E_{\text{rot}}^2$  decreases,  $E_{\text{rel}}^2$  increases, enabling the system to cross into a lower causal frame. This mirror-divergent perspective allows energy conservation to remain valid even as causal connectivity is lost.

In this way, Frame Drag Braking becomes a reinterpretation of cosmological acceleration and energy flow in a layered universe, conserving energy relativistically across both frames. (see Figure 1).

This also recasts the cosmological redshift. From within our descending frame, distant galaxies appear to redshift more and more. But this may be a mirror illusion: we are falling, not they. Our descent makes even the stationary look receding.

The redshift we observe is symmetrical: both the galaxy and the surrounding dark matter see each other as redshifted. This phenomenon, called **Mirror Divergence**, reflects causal disconnection; Only one frame is truly descending.

This framework also helps resolve the long-standing puzzle of dark energy. From within our relatively low-energy frame, we observe high-redshift systems and interpret their separation as evidence of universal acceleration. But if we ourselves are descending through causal frames, the apparent redshift of those distant galaxies may be due to our own change in frame, and not their motion away.

*Our car rolls backward, and we perceive that the parked car next to us is rolling forward.*

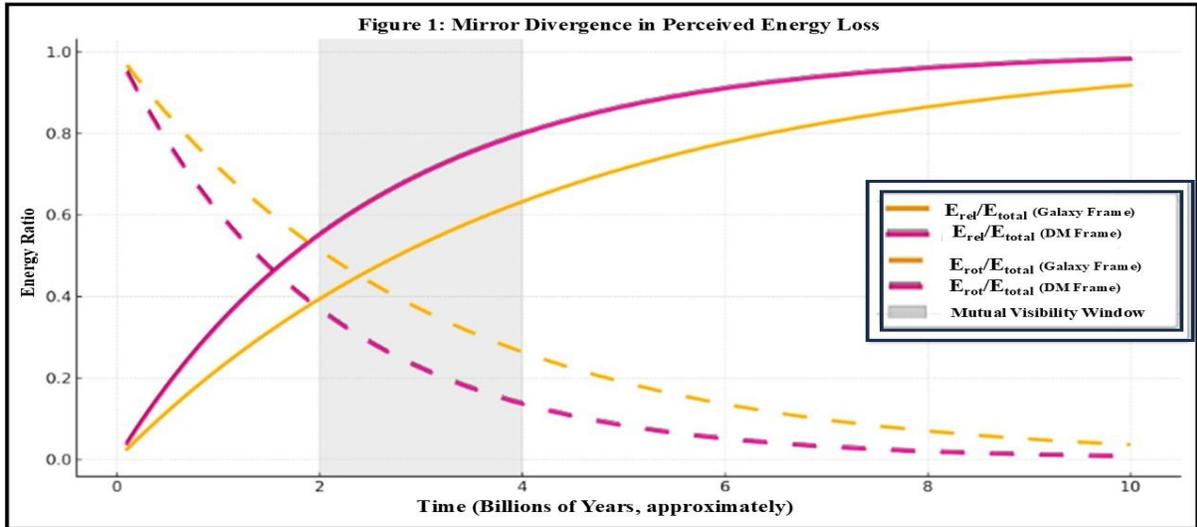


Figure 1. This chart illustrates the asymmetric perception of energy ratios between the Galaxy Frame and the Dark Matter (DM) Frame over time. Solid lines represent the ratio of relativistic energy  $E_{rel}/E_{total}$ , while dashed lines represent the localized or retained energy  $E_{rot}/E_{total}$  as perceived within each frame. The shaded region marks the Mutual Visibility Window—an approximate temporal span during which both structures remain causally visible to each other. After divergence, each frame perceives the other as increasingly energy-depleted due to redshift, though total energy is conserved across both frames via geometric continuity in spacetime.

Kirk Value ( $K_k$ )	Time Rate (T)	Effective Year Length
-1.0	707	0.52 hours
-0.75	133	2.74 days
-0.5	26.6	13.7 days
-0.25	5.15	70.9 days
0.0	1.0	365 days (1 yr)
+0.25	0.194	1880 days (5.15 yrs)
+0.5	0.038	9605 days (26.3 yrs)
+0.75	0.0074	49,324 days (135 yrs)
+1.0	0.0014	260,000 days (712 yrs)

Kirk Value ( $K_k$ )	Time Rate (T)	Effective Duration
-1.0	707.1	2.04 min
-0.75	137.123102	10.5 min
-0.5	26.591352	54.15 min
-0.25	5.15668	4.65 hr
0.0	1.0	1.0 days
0.25	0.193923	5.16 days
0.5	0.037606	26.59 days
0.75	0.007293	137.12 days
1.0	0.001414	1.94 yrs

Figure 2. Time rate progression across Kirk values: top chart normalized to 1 year at  $K = 0$ , bottom chart to 1 day at  $K = 0$ .

## **Closing Thoughts:**

### **Black Holes**

Black holes are usually described as singularities or gravitational wells with no escape. But in this framework, a black hole may simply be a region where matter has inertially descended—fallen so far through the gravitational frame gradient that it has slipped below our Causal Horizon. From our perspective, that region is causally disconnected. We cannot observe it, or exchange information with it. But its gravitational influence remains. Of course it does; Gravity operates across frames. It would be stranger if it didn't. In that sense, a black hole behaves exactly like dark matter. Not because it *is* dark matter, but because it shares the same condition: causal disconnection.

### **The Relative Age of the Universe**

We often say the universe is 13.8 billion years old, as if there were one clock keeping the master time of everything. But time, like causality, is frame-dependent. Structures in different frames, moving at different velocities or under different gravitational conditions, age differently.

This isn't some modern revision. It's been there from the start. The Lorentz Transformation doesn't create this; it simply reveals it. Yet we continue to act as if a universal clock exists somewhere—God's wristwatch—ticking away the true age of the universe for all frames at once. We seem to have a psychological *need* for the universe to conform to our clock. But the universe has no obligation to match the rhythm of our clocks.

### **But why 13.8 billion years?**

Because Edwin Hubble saw redshifts and interpreted them in the only way he knew: the Doppler effect. Everything appeared to be moving away from everything else. It looked like an explosion. So we brought in the bomb squad and did the logical thing—we worked backwards. We traced the trajectories to their point of origin and tried to reconstruct the scene. That was the first domino.

From there, every new observation was placed carefully into the same story. The expansion. The structure. Even the age of the universe, which we already knew was frame-dependent, was folded into a single timeline.

The Layered Causality Hypothesis didn't set out to dispute the story of the universe. It set out to explain dark matter. But telling that story in full—carefully, and in detail—meant checking every step. And eventually, some of those early dominos began to wobble.

## The End of the Big Bang

If the Big Bang never happened as a real event, but as a myth born of frame-limited perception, then nearly every major inference drawn from it must be reconsidered.

If there is no Big Bang...

- ...then there is no universal expansion.
- ...then there is no cosmic acceleration.
- ...then the universe does not have a singular age.
- ...then spacetime cannot expand faster than light, only appear to do so across disconnected causal domains.
- ...then warp drives are likely impossible, because space cannot be manipulated to exceed light speed, even “indirectly.”
- ...then dark energy is not a force, but a misreading of redshifts.
- ...then the cosmic microwave background is not the afterglow of a singular origin, but the accumulated leakage of uncertainty and residual energy across infinite causal ranges; scraps of interaction from an unknowable and possibly infinite past.
- ...then we must reimagine the entire visible cosmos not as the origin, but as a structured expression of something larger, faster, and more causally distant.

## Testable Predictions and Empirical Implications

### 1. Gravitational Lensing from Extremely Redshifted Objects

**Prediction:** Galaxies or structures with redshift values exceeding  $z \approx 12$  will still produce strong gravitational lensing observable from our frame.

**Test:** Compare lensing signatures of  $z \sim 12+$  objects (e.g. JADES-GS-z14-0) with the absence of corresponding visible or EM signals. If gravitational effects persist but no other forces are detectable, this supports LCH.

### 2. Angular Size Anomaly at High Redshift

**Prediction:** Objects with extremely high redshift ( $z > 10$ ) may not show the angular size reduction expected from classical expansion. If redshift is due to causal frame divergence, angular size could appear larger than expected.

**Test:** Plot angular size vs. redshift; deviation from the  $\Lambda$ CDM prediction curve at high- $z$  may indicate frame-based redshift.

### 3. No Detection of Quantum Coherence Across the Jones Threshold

**Prediction:** Quantum coherence (e.g., entanglement or phase alignment) will not persist across frame separation corresponding to  $z \approx 0.58$  or velocities near  $0.8c$ .

**Test:** Test long-distance entanglement over relativistic velocity separations. Loss of coherence near the Jones Threshold would confirm LCH predictions about inter-frame decoherence.

### 4. Asymmetry in Clock Rate Perception (Mirror Divergence)

**Prediction:** Observers in two causally disconnected frames will perceive opposite effects on the other's clock: one appears to slow, the other to accelerate.

**Test:** Analyze timekeeping in high-velocity probes or systems approaching relativistic separation. Look for asymmetries in clock drift that defy standard symmetric time dilation.

### 5. Cosmic Microwave Background (CMB) Reinterpretation

**Prediction:** CMB may show small directional anisotropies or spectral distortions correlated with known dark matter structures, as it represents energy leakage across causal frames.

**Test:** Cross-correlate CMB anomalies with large-scale structure maps. Consistent alignment could support causal leakage rather than Big Bang origin.

### 6. RIP Conservation Across Frame Descent

**Prediction:** Galaxies losing angular momentum will show a proportional increase in redshift or clock-rate shift, preserving the total energy interval per  $E^2_{\text{total}} = E^2_{\text{rot}} + E^2_{\text{rel}}$ .

**Test:** Observe galaxies with declining spin; track correlated increases in external redshift or inferred temporal shift.

### 7. Time Perception Compression in Higher Frames

**Prediction:** Higher causal frames will perceive our entire cosmic history as compressed, with lower observable event complexity per unit time.

**Test:** Simulate observations from causally elevated frames and analyze predicted entropy growth rates or observable timeline complexity.

## 8. Visibility will cease before the Schwarzschild radius is reached.

**Prediction:** From the perspective of a stationary observer, the region surrounding a black hole will begin to dim before the Schwarzschild boundary is crossed. This fading corresponds to the approach of the Causal Horizon, beyond which electromagnetic interaction becomes impossible. The ‘black’ horizon—what appears to be the edge—should begin forming at approximately  $0.03 K_k$  before the Causal Horizon is reached. This transition is not a sharp boundary, but a narrow, fuzzy threshold representing the final sliver of causal visibility.

**Test:** Compare observed dimming profiles of infalling matter near black holes against predicted redshift values. If light fades significantly before the calculated Schwarzschild radius, and the rate of dimming aligns with the final  $.03 K_k$  approach to the Causal Horizon, this would support the hypothesis that visibility loss is tied to frame disconnection rather than escape velocity alone.

## References

1. Ortiz, C., & Ibarra-Castor, F. (2024). *Generalized redshift formula through an energy-based framework*. Scientific Reports. <https://doi.org/10.1038/s41598-024-56188-1>
2. Gray, N., & Dunning-Davies, J. (2008). *Entropy and velocity: A reconsideration*. arXiv preprint arXiv:0811.2541.
3. Vagnozzi, S. (2024). *Reinterpreting cosmic redshift in modified frameworks*. arXiv:2407.10622.
4. Einstein, A. (1905). *Zur Elektrodynamik bewegter Körper*. Annalen der Physik, 17, 891–921. [Special Relativity]
5. Planck, M. (1901). *On the Law of Distribution of Energy in the Normal Spectrum*. Annalen der Physik.
6. Lense, J., & Thirring, H. (1918). *On the influence of the proper rotation of central bodies on the motion of planets and moons according to Einstein’s theory of gravitation*. Physikalische Zeitschrift, 19, 156–163.
7. Kerr, R. P. (1963). *Gravitational field of a spinning mass as an example of algebraically special metrics*. Physical Review Letters, 11(5), 237–238.
8. Penrose, R. *The Road to Reality: A Complete Guide to the Laws of the Universe*. Jonathan Cape, 2004.  
Penrose, R. “On Gravity’s Role in Quantum State Reduction,” *Gen. Rel. Grav.* 28, 581–600 (1996).
9. Hameroff, S., & Penrose, R. “Consciousness in the Universe: A Review of the ‘Orch OR’ Theory.” *Physics of Life Reviews*, 11(1), 39–78 (2014).