

# The Layered Causality Hypothesis

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*Reinterpreting Relativity to Include Dark Matter*

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# The Kirk Coordinate

A Logarithmic Measure of Time-Rate Separation in Relativity

The Layered Causality Hypothesis Part I

Mark Rehl • August 2025

## Abstract

Historical treatments of time dilation rely on parameters such as Lorentz factor  $\gamma$ , velocity fraction  $\beta$ , or rapidity  $\phi$ . While mathematically effective, these forms can obscure scaling, separate velocity- and gravity-induced effects, and make cross-cause comparisons clumsy. In this paper we introduce a *logarithmic time-rate coordinate*, called the Kirk, which is agnostic to the underlying cause of dilation. The Kirk provides a common ruler for comparing inertial frames, simplifying both analysis and communication. By recasting time dilation in terms of a uniform unit of measure, this framework offers a clearer way to visualize inertial frames and interpret phenomena ranging from special relativistic velocity effects to gravitational redshift.

## 1 Introduction: A Word of Explanation from the Author

When thinking about inertial frames, particularly their time dilation aspect, the Lorentz Transformation provides a reliable way to calculate data [1, 2]. However, it does so through velocity, often approaching inertial frames indirectly by describing rate and distance changes. For those of us who try to visualize concepts, this can make inertial frames feel abstract. What is an inertial frame, really?

I tend to think of it as a place — a place where all clocks and rulers agree. But it is also, metaphorically, a road that can be traveled: to the north lie faster clocks, to the south slower clocks. Roads in the physical world are measured in miles or kilometers. If we are to imagine traveling along a road of inertial frames, why shouldn't we have a unit of measure as well?

Enter the Kirk.

I have defined one Kirk in a way that is sensible for the work presented here, though it is not arbitrary. It is a constructed “ruler” designed to simplify the temporal aspects of inertial frames, and I propose it as a useful general tool for visualizing and comparing time rates across frames.

## 2 Definition of the Kirk Coordinate

$$K_\kappa \equiv \log_b(\gamma), \quad b > 1, \quad (1)$$

so  $\gamma = b^{K_\kappa}$ . The base  $b$  is conventional;  $b = 10$  makes each unit step a tenfold change in time-rate separation.

**Special Relativity (velocity-induced).**

$$\gamma = \frac{1}{\sqrt{1 - \beta^2}}[1], \quad \beta = \frac{v}{c}, \quad \Rightarrow \quad \gamma = b^{K_\kappa}. \quad (2)$$

Inverse map:

$$\beta = \sqrt{1 - b^{-2K_\kappa}}. \quad (3)$$

**General Relativity (Schwarzschild, stationary clocks).**

$$\gamma = \frac{1}{\sqrt{1 - \frac{2GM}{rc^2}}}[4] \quad \Rightarrow \quad K_\kappa = \log_b \left( \frac{1}{\sqrt{1 - \frac{2GM}{rc^2}}} \right). \quad (4)$$

**Relation to rapidity  $\phi$ .** Since  $\gamma = \cosh \phi$  and  $\beta = \tanh \phi$ ,

$$K_\kappa = \log_b(\cosh \phi), \quad \phi = \operatorname{arctanh}(\beta)[3]. \quad (5)$$

With  $b = e$ ,  $K_\kappa = \ln \gamma$  and the substitution  $\gamma = e^{K_\kappa}$  makes any Lorentz/rapidity expression immediately interchangeable with Kirk (using  $\cosh \phi = \gamma$  and  $\tanh \phi = \beta$ ).

### 3 Simplifying Relativistic Relationships

**Kinetic energy fraction**

$$\frac{K}{mc^2}[1] = \gamma - 1 = b^{K_\kappa} - 1. \quad (6)$$

**Proper-time suppression**

$$1 - \frac{1}{\gamma} = 1 - b^{-K_\kappa}. \quad (7)$$

**Partition ratio (motion energy : time suppression)**

$$\frac{\frac{K}{mc^2}}{1 - \frac{1}{\gamma}} = \frac{\gamma - 1}{1 - \gamma^{-1}} = \gamma = b^{K_\kappa}. \quad (8)$$

### 4 Kirk numbers and the Lorentz Transformation

The Lorentz time-dilation relation

$$d\tau = \frac{dt}{\gamma} \quad (9)$$

combined with the Kirk definition  $K_\kappa = \log_b(\gamma)$  (so  $\gamma = b^{K_\kappa}$ ) gives an immediate *time-rate converter*:

$$\Delta\tau(K_\kappa) = b^{-K_\kappa} \Delta t = \frac{\Delta t}{\gamma}. \quad (10)$$

Thus a specified Kirk value converts any interval  $\Delta t$  measured in the zero frame ( $K_\kappa = 0$ ) into the proper time  $\Delta\tau$  in the frame at  $K_\kappa$ —no velocity needed.

### Example A: Directly from a Kirk value

Let  $b = 10$ ,  $K_\kappa = 0.5$ , and  $\Delta t = 1$  hour. Then

$$\Delta\tau(0.5) = 10^{-0.5} \times 1 \text{ hr} = \frac{1}{\sqrt{10}} \text{ hr} \approx 0.316 \text{ hr} \approx 19 \text{ min.}$$

A single Kirk number produced the conversion in one step.

### Example B: Match to a Lorentz (velocity) case

Take  $v = 0.8c$ , so  $\gamma = \frac{1}{\sqrt{1-0.8^2}} = \frac{1}{0.6} = 1.666\dots$  With  $b = 10$ ,

$$K_\kappa = \log_{10} \gamma \approx 0.22185, \quad \Delta\tau = 10^{-K_\kappa} \Delta t \approx 0.6 \Delta t,$$

which is exactly the Lorentz result  $\Delta\tau = \Delta t/\gamma$ . (With  $b = e$ ,  $K_\kappa = \ln \gamma \approx 0.5108$  and  $\Delta\tau = e^{-K_\kappa} \Delta t \approx 0.6 \Delta t$ .)

### When velocity or rapidity are desired

Kirk interfaces cleanly with standard kinematics:

$$\beta = \sqrt{1 - b^{-2K_\kappa}}, \quad v = \beta c, \quad K_\kappa = \log_b(\cosh \phi), \quad \phi = \operatorname{arctanh}(\beta). \quad (11)$$

These identities show that Kirk does not replace Lorentz; it *expresses* Lorentz time-rate differences on a logarithmic ruler and hands back  $(\gamma, \beta, \phi)$  when needed.

### Note on base

All formulas above hold for any  $b > 1$ . Changing base rescales the horizontal axis; the converter (10) keeps the same form:

$$\Delta\tau(K_\kappa) = b^{-K_\kappa} \Delta t = e^{-K_\kappa \ln b} \Delta t.$$

## 5 Applications Beyond SR

**Education.** Kirk reduces  $\beta$ – $\gamma$  confusion and gives students “Kirk steps” as intuitive multiplicative changes in time rate.

**Engineering.** Mission planning and clock management *including GPS/GNSS satellite clocks* benefit from a single coordinate that combines velocity- and gravity-induced time-rate effects on one axis, avoiding mixed  $\beta$  expansions and manual cross-cause reconciliations.

**Research.** A common currency for juxtaposing relativistic phenomena from different origins; a natural x-axis for comparative studies.

**Theory.** Integrates cleanly with causal-structure models that emphasize time-rate separation (e.g., using an  $E \cdot T$  bound), without committing to any particular mechanism that generates  $\gamma$ .

## 6 Figures

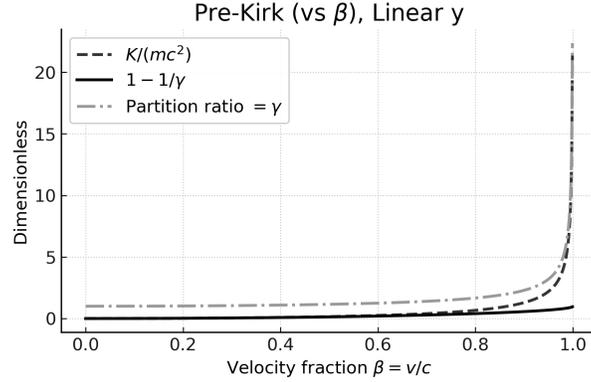


Figure 1: Pre-Kirk view versus velocity fraction  $\beta = v/c$  (linear  $y$ ). Curves for kinetic-energy fraction, proper-time suppression, and the partition ratio  $\gamma$  crowd and steepen near  $\beta \rightarrow 1$ .

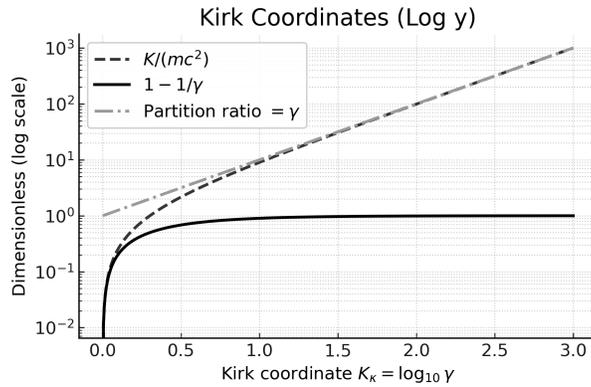


Figure 2: Kirk coordinates with  $K_\kappa = \log_{10} \gamma$  ( $\log y$ ). Scaling is linearized and the partition ratio becomes a simple exponential, separating curves that overlap in the pre-Kirk view.

## References

- [1] A. Einstein, *Zur Elektrodynamik bewegter Körper*, Ann. Phys. **17** (1905).
- [2] H.A. Lorentz, *Electromagnetic phenomena in a system moving with any velocity less than that of light*, Proc. Roy. Acad. Amsterdam (1904).
- [3] W. Rindler, *Relativity: Special, General, and Cosmological*, Oxford University Press (2006).
- [4] K. Schwarzschild, *Über das Gravitationsfeld eines Massenpunktes*, Sitzungsberichte der Königlich Preussischen Akademie der Wissenschaften (1916).

# The Causal Horizon Law

The Layered Causality Hypothesis Part II

Mark Rehl – August 2025

## Abstract

This paper isolates and develops the *Causal Horizon Law*. The law states that causal interaction between inertial frames ends when the condition

$$E \cdot T = h$$

is satisfied, with  $E$  representing the characteristic energy of a system and  $T$  the relative time separation between frames. At this limit, no exchange of information through electromagnetic, weak, or strong interactions is possible. Only gravity, as the shared floor of spacetime geometry, remains as a channel of influence. We present multiple, independent derivations of this limit, including dimensional analysis, Fourier single-cycle reasoning, Lorentz–Kirk time-rate conversion, partial-trace coherence bounds, phase-drift accumulation, and the breakdown of simultaneity. All converge on the same principle: causal interaction has a finite horizon.

## Introduction: A Word from the Author

In Part 1 of this series, we introduced the Kirk metric. One of its benefits is that it aids in visualizing inertial frames. It was while visualizing them that the seed of this series first took root. Because there is no preferred frame[1], and because inertial frames, in principle, extend infinitely, it occurred to me that we live in only a very small part of that infinity. Whether or not the dimensions of space extend forever, inertial frames may do so independently—and that is the present understanding of physics.

It then became clear that since time slows in the direction of higher-energy frames and distances compact, distant frames would eventually become meaningless to us, unable to interact with us in any conventional way. Then came the critical turn: if such frames exist, then matter may exist in them as well. And if matter exists there, so too may observers—each finding that, from their vantage point, “everything appears normal.” This simple insight suggested that what we call dark matter might in fact be nothing more than ordinary matter that is inertially distant—far enough removed that it interacts with us only through the shared fabric of gravity.

In Part 1 we stated that the  $K_k = 1$  setting was not arbitrary, but did not elaborate. In Part 2 we now assign the following values in advance of deriving them:

- $K_k = 0$ : the observer’s frame, wherever they may be along the continuum of inertial frames.
- $K_k = \pm 1$ : the Causal Horizon, with the  $+$  direction pointing toward higher-energy frames and the  $-$  direction toward lower-energy frames.

Here we will show that the barrier to interaction with distant frames occurs precisely at  $\pm 1$  Kirk, where the condition

$$E \cdot T = h$$

is satisfied. At this threshold, causal interaction through any means but gravity ceases, leaving gravity as the sole shared foundation of spacetime geometry.

## 1 Derivations of the Causal Horizon Law

We present several independent routes that converge on the same boundary condition for sustained causal connection:

$$\boxed{E \cdot T = h}, \tag{1}$$

interpreted here as a *coherence/connection* limit (not a measurement-uncertainty statement). When  $ET < h$ , non-gravitational channels cannot maintain resolvable phase relations and thus cannot carry information coherently.

### 1.1 (1) Dimensional and symmetry argument

Action carries units of energy $\times$ time. If there exists a universal, frame-agnostic boundary for coherent interaction, it must be proportional to Planck's constant:

$$ET = Ch. \tag{2}$$

Fixing  $C = 1$  by the single-cycle criterion (Sec. 1.2) yields

$$\boxed{E \cdot T = h}$$

### 1.2 (2) Fourier single-cycle criterion

For a channel of frequency  $f$  (energy  $E = hf$ ) observed over a time window  $T$ , at least one resolvable oscillation is required:

$$fT \geq 1 \implies hfT \geq h \implies E \cdot T \geq h. \tag{3}$$

At the boundary,

$$\boxed{E \cdot T = h}$$

This argument is cause-agnostic: any carrier that reduces to an oscillatory mode in the observer's frame obeys it.

### 1.3 (3) Lorentz–Kirk time-rate route

The Lorentz relation  $d\tau = dt/\gamma$ [2, 3] together with the Kirk definition  $K_k = \log_b \gamma$  gives a one-step time-rate converter:

$$\Delta\tau(K_k) = b^{-K_k} \Delta t = \frac{\Delta t}{\gamma}. \tag{4}$$

A source with proper frequency  $f_{\text{src}}$  is seen with  $f_{\text{obs}} = f_{\text{src}}/\gamma$ . Over an integration time  $T$ ,

$$f_{\text{obs}} T = \frac{f_{\text{src}}}{\gamma} T \geq 1 \quad \Rightarrow \quad E_{\text{obs}} T = (hf_{\text{obs}}) T \geq h. \quad (5)$$

Thus the boundary is

$$\boxed{E \cdot T = h}$$

**Not a “speed limit approach”.** This construction uses *time-rate ratios*, not proximity to  $c$ . For example, placing  $K_k = 1$  at  $\gamma_{\text{max}} = 707$  corresponds to  $v/c \approx 0.999999$ , but this is no “closer to  $c$ ” than the reader is right now: light speed remains unattainable, and the horizon is defined by coherence, not by kinematic approach to  $c$ .

#### 1.4 (4) Partial-trace coherence bound (density-matrix view)

This subsection expresses entanglement collapse in the density-matrix formalism. Consider a system  $S$  entangled with an environment  $E$ , with joint evolution

$$U(T) = e^{-iHT/\hbar},$$

and reduced state

$$\rho_S(T) = \text{Tr}_E[U(T) \rho_{SE} U^\dagger(T)]. \quad (6)$$

Here  $S \otimes E$  could represent two entangled particles, two subsystems associated with observers, or—within the LCH framework—a system where one partner has crossed a causal boundary (e.g. beyond  $K_\kappa = 1$ ). Tracing out  $E$  corresponds to the accessible observer losing information about the disconnected partner.

Off-diagonal terms in  $\rho_S$  acquire environment-dependent phases that average out under the trace. For an effective environmental spectral width  $\Delta E$ , the coherence factor behaves like a Fourier transform envelope:

$$|\mathcal{C}(T)| \lesssim \left| \text{sinc}\left(\frac{\Delta E T}{2\hbar}\right) \right|. \quad (7)$$

As  $T$  grows, the off-diagonal coherence vanishes, and  $\rho_S$  reduces to a classical mixture rather than a superposition. Physically this is the mathematical signature of entanglement collapse from the viewpoint of the surviving subsystem.

Coherence collapses once  $\Delta E T \gtrsim \hbar$ , reproducing the same boundary (with  $E$  identified to the effective interaction scale):

$$\boxed{E \cdot T \simeq h}$$

#### 1.5 (5) Phase decoherence via relativistic drift

Let two initially phase-locked systems have phases  $\phi_i = kx_i - \omega_i t_i$  with wavefunctions  $\psi_i \propto e^{i\phi_i}$ . Relativistic drift between frames produces  $t_2 = t_1/\gamma$  (and frequency shift  $\omega_2 = \omega_1/\gamma$  for the same proper source). The relative phase accumulates as

$$\Delta\phi(t) = \phi_2 - \phi_1 = k \Delta x - \omega_1 t + \frac{\omega_1}{\gamma} t = k \Delta x - \omega_1 \left(1 - \frac{1}{\gamma}\right) t. \quad (8)$$

For sustained interference,  $|\Delta\phi| \lesssim \mathcal{O}(1)$  over the observation window. Equivalently, the observable frequency  $f_{\text{obs}} = \omega_1/(2\pi\gamma)$  must satisfy  $f_{\text{obs}}T \gtrsim 1$ , which restates the single-cycle bound and hence  $ET \gtrsim h$ . Otherwise  $\Delta\phi$  wanders beyond control and phase coherence is lost.

## 1.6 (6) Breakdown of simultaneity and shared unitary

Large separations in time-rate imply loss of a shared simultaneity slice between frames. Without a consistent ordering of events, no single global unitary evolution can be assigned that both observers agree on for exchanged signals. Operationally, the shared state description degrades to a classical mixture when coarse-grained across incompatible slices—again matching the practical loss of coherence captured compactly by

$$\boxed{E \cdot T = h}$$

### Summary

Dimensional reasoning, the single-cycle Fourier bound, Lorentz–Kirk time-rate conversion, partial-trace coherence limits, phase-drift accumulation, and simultaneity breakdown all converge on the same horizon condition:

$$\boxed{E \cdot T = h}$$

The Causal Horizon Law provides a sharp and universal boundary condition for interaction across inertial frames. If matter exists beyond this boundary, it would be invisible through conventional forces and detectable only by its gravitational effects — consistent with what is observed as dark matter.

### Note on the Jones Threshold

Before the discovery of the Causal Horizon Law, we sought a “causal cutoff” and identified what became known as the Jones Threshold. This threshold marks the point where light (and, more generally, any wavelength-based interaction) becomes so redshifted that it is effectively invisible and unobtainable before the Causal Limit is reached. The threshold is element- and particle-specific, producing a “fuzzy line” rather than a sharp boundary. The region of Kirkspace that lies between the Jones Threshold and the Causal Limit is referred to as the Jones Window.

## References

- [1] A. Einstein, “Zur Elektrodynamik bewegter Körper,” *Annalen der Physik*, vol. 17, pp. 891–921, 1905.
- [2] H. A. Lorentz, “Electromagnetic phenomena in a system moving with any velocity less than that of light,” *Proceedings of the Royal Netherlands Academy of Arts and Sciences*, 1904.
- [3] W. Rindler, *Relativity: Special, General, and Cosmological*, 2nd ed. Oxford University Press, 2006.

# Inertial Frame Realignment

and the Twin Paradox - Paradox

The Layered Causality Hypothesis Part III

Mark Rehl • August 2025

## Abstract

When considering the well-known Twin Paradox, one notices that standard relativistic accounts do not provide a clear mechanism by which divergent inertial frames become realigned. This work isolates and formalizes that mechanism in the form of the Rehl Inertial Frame Realignment Theorem, which states that gravitational capture or collision enforces time-rate alignment between previously separated frames. We also introduce a speculative boundary condition at one Kirk unit ( $1K_\kappa$ ), suggesting a limit beyond which realignment cannot occur. Together these results situate inertial realignment as a necessary complement to special relativity, with implications for the broader framework of layered causality.

## Introduction: A Word from the Author

Anyone who has studied relativity knows the story of the twin paradox: one twin stays on Earth while the other zips off at relativistic speeds. When the traveling twin returns home, he finds that he has not aged as much as his earthbound brother. This is the standard time dilation story — acceleration makes your clock run slow.

But something about this tale always bothered me. I waved it off, thinking, “Surely people more knowledgeable than me understand this.” What I had unconsciously realized was that there is no actual way, within the story, to reverse the process — no way to “speed the clock back up” so the traveling twin can have a normal conversation with his brother again.

The usual thought is that deceleration realigns time. But this doesn’t actually make sense. When the twin fires his rockets and leaves Earth’s influence, his attempt to throw energy into space has the equal and opposite effect of pushing him into a higher inertial frame where clocks run slower. Eventually, he settles into his cruising speed — say, half the speed of light relative to Earth — and now he is in a new inertial frame. The universe does not keep a record of where he came from. It does not remember his previous frames.

Therefore, when he fires his retro-rockets, he does not, in any universal sense, “decelerate.” He merely pushes more energy into the universe, and the result is that his clock slows down even further. By this logic, every time he tries to insert energy into the universe at large, the universe responds by slowing his clock some more.

But don’t worry about our hero. I suspected that gravity must provide the missing piece — that the gravitational well of Earth realigns inertial frames when it captures you in orbit, or when you crash into its surface. Surely this was standard, I thought, and went looking for someone who

had proven it mathematically. It seemed like low-hanging fruit. I assumed I would quickly find someone to cite, showing that Earth and other large gravitational wells realign inertial frames.

To date, I have found no such proof. So I worked it out myself, in the form of a theorem. I felt sheepish the whole time, assuming it must belong to someone else, and that I should give them credit. Still, wanting it for this work, I wrote it myself and tempted fate by giving it my name.

If the reader knows of someone who reached this conclusion before me, whether long ago or yesterday, I would be grateful to learn of it, and will gladly withdraw this claim and credit whoever it properly belongs to. Until then, I present to you the Rehl Inertial Frame Realignment Theorem.

## The Rehl Inertial Frame Realignment Theorem

Here, we present the Rehl Inertial Frame Realignment Theorem, which states that gravitational capture or collision enforces alignment of inertial frames. This formulation connects classical relativistic mechanics with the observed behavior of captured systems.

### Physical Background

We begin with several key elements of general relativity and differential geometry:

– The four-velocity describes motion through spacetime. The norm condition in natural units is

$$u^\alpha u_\alpha = -1, \quad (\text{in natural units, metric signature } - + + +) \quad (1)$$

which ensures that the object's four-velocity has unit magnitude in spacetime [2].

– Free particles move along geodesics, which satisfy

$$\frac{dP^\alpha}{d\tau} = 0, \quad (2)$$

while in curved spacetime the covariant form becomes

$$\frac{dP^\alpha}{d\tau} = \Gamma_{\beta\gamma}^\alpha P^\beta u^\gamma, \quad (3)$$

which describes how four-momentum changes due to spacetime curvature [3].

– The Einstein field equations relate energy-momentum to spacetime geometry:

$$G_{\mu\nu} = 8\pi T_{\mu\nu}, \quad (4)$$

and a gravitational gradient induces a nonzero four-force,

$$\frac{dP^\alpha}{d\tau} = f^\alpha, \quad (\text{aligned with the gravitational gradient}) \quad (5)$$

which pulls the captured body into alignment with the gravitational frame [1].

## Lemma: Gravitational Alignment Principle

Let  $v^\alpha$  be the four-velocity of a captured object and  $\xi^\alpha$  the timelike Killing vector of the gravitational field. Then

$$v^\alpha \propto \xi^\alpha, \quad (\text{up to normalization}) \quad (6)$$

which shows that the object's motion becomes aligned with the gravitational time flow near capture.

## The Rehl Inertial Frame Realignment Theorem

**Statement:** In a gravitational field, the capture or collision of a system into a more massive body enforces alignment of the captured object's four-velocity with the local gravitational frame. This alignment occurs due to the nonzero four-force induced by spacetime curvature, and the evolution of the object's four-velocity converges with that of the gravitational source as proper time approaches the capture moment.

Formally:

$$\boxed{u^\mu \longrightarrow U^\mu \text{ as } \tau \rightarrow \tau_0} \quad (7)$$

Here,  $u^\mu$  is the four-velocity of the captured object and  $U^\mu$  is the local frame defined by the gravitational source, and  $\tau$  is the proper time interval.

## Causal Disconnection Limit

The preceding theorem demonstrates that gravitational curvature enforces inertial frame realignment during capture. However, this result assumes that the captured system remains causally connected to the gravitational source. In the Layered Causality framework, this assumption fails at a frame separation of  $\Delta K = 1$ , where proper time intervals between frames become incomparable and four-velocity alignment loses physical meaning.

Here,  $\Delta K$  is the Kirk-coordinate (described in the next section) separation between frames, with  $\Delta K = 1$  representing the causal disconnection limit defined by the Causal Horizon Law,

$$E \cdot T = h.$$

This threshold is not an arbitrary cutoff, but an emergent boundary derived from foundational constraints:

- **Clock synchronization requires causal exchange:** Without a shared spacetime structure, no coherent comparison of proper time is possible.

- **Geodesic connection presupposes causal contact:** In disconnected frames, no spacetime path exists for alignment to proceed.

- **The Causal Horizon Law ( $E \cdot T = h$ ):** This imposes a fundamental limit on coherent interaction, beyond which  $T \rightarrow \infty$  and  $E \rightarrow 0$ , effectively freezing relational dynamics.

Thus, the realignment process defined in the theorem is only valid when  $\Delta K < 1$ . Beyond this threshold, no synchronization or convergence of time rates is physically defined.

We formalize this causal limit as:

$$\boxed{\Delta K \longrightarrow 1 \Rightarrow \text{Causal Disconnection}} \quad (8)$$

## Interpretation and Implications of the Realignment Limit

The preceding theorem shows that gravitational systems undergoing capture or collision are not merely influenced by curvature; they are dynamically realigned. This process is enforced by the induced four-force and expressed through the convergence of time rates, via four-velocity alignment in spacetime.

This result offers a classical analog to the Penrose–Hameroff Orchestrated Objective Reduction (Orch-OR) model[9], which proposes that when mass distributions differ between quantum states, gravity induces collapse into a single geometry. Their governing expression,

$$E_G \cdot \tau = \hbar,$$

bears a striking resemblance to our own Causal Horizon Law,

$$E \cdot T = h.$$

Though Penrose and Hameroff refer to quantum geometries and LCH refers to causal frames, both models suggest a fundamental instability when systems attempt to straddle incompatible states. As frame misalignment increases, systems approach the causal boundary at  $\Delta K = 1$ . Beyond this point, the concept of enforced realignment breaks down entirely. The system may instead undergo collapse, fragmentation, or disconnection. While the full dynamics of such behavior lie outside the scope of the current theorem, the conceptual parallel remains: both frameworks treat gravitational structure as enforcing coherence within definable limits, and both predict instability when those limits are exceeded.

This resonance suggests a deeper commonality: whether addressing conscious collapse or relativistic descent, gravity appears to resist the sustained multiplicity of frames. Collapse, whether quantum or causal, may represent the natural gravitational mechanism for restoring coherence across divergent states.

## Neutrinos and the Realignment Boundary

Neutrinos provide a natural test of the realignment boundary because they possess tiny but nonzero rest mass while often carrying large kinetic energies [?, ?]. In the ultra-relativistic regime the Lorentz factor is well-approximated by

$$\gamma \approx \frac{E}{m_\nu c^2}, \tag{9}$$

and the Kirk coordinate (defined by  $K = \log_{707} \gamma$ ) gives

$$K = \frac{\ln \gamma}{\ln 707}. \tag{10}$$

For a representative neutrino mass  $m_\nu \approx 0.05 \text{ eV}/c^2$ , we obtain:

$E$	$\gamma$	$K$	$E$	$\gamma$	$K$
1 MeV	$2 \times 10^7$	2.56	1 TeV	$2 \times 10^{13}$	4.67
1 GeV	$2 \times 10^{10}$	3.62	1 PeV	$2 \times 10^{16}$	5.72

We formalize the causal limit separating these cases as:

$$\boxed{\tau = \frac{h}{\Delta E}, \quad \Delta K < 1 \quad \quad \tau = \text{undefined}, \quad \Delta K \geq 1} \quad (11)$$

Thus, neutrinos commonly detected from solar, atmospheric, accelerator, and astrophysical sources satisfy  $K > 1$  relative to our frame, placing them beyond the proposed realignment domain ( $\Delta K < 1$ ). In that regime, the realignment mechanism described earlier would not apply:

$$K_\nu > 1 \quad \Rightarrow \quad \text{outside realignment reach (no enforced } u^\mu \rightarrow U^\mu\text{)}. \quad (12)$$

By contrast, relic neutrinos from the early universe today are expected to be non-relativistic, with  $K < 1$ . These would remain within causal range and therefore subject to the realignment process[7]. The contrast between relic and high-energy neutrinos illustrates how the causal disconnection limit partitions physical systems: some remain realignable, others exist permanently outside the domain of inertial capture.

## References

- [1] A. Einstein, “Die Feldgleichungen der Gravitation,” *Sitzungsberichte der Königlich Preußischen Akademie der Wissenschaften* (1915), 844–847.
- [2] R. M. Wald, *General Relativity*, University of Chicago Press, 1984.
- [3] C. W. Misner, K. S. Thorne, J. A. Wheeler, *Gravitation*, W. H. Freeman, 1973.
- [4] R. L. Workman et al. (Particle Data Group), “Review of Particle Physics,” *Progress of Theoretical and Experimental Physics*, 2024, 083C01.
- [5] Y. Fukuda et al. (Super-Kamiokande Collaboration), “Evidence for Oscillation of Atmospheric Neutrinos,” *Physical Review Letters* 81, 1562 (1998).
- [6] Q. R. Ahmad et al. (SNO Collaboration), “Direct Evidence for Neutrino Flavor Transformation from Neutral-Current Interactions in the Sudbury Neutrino Observatory,” *Physical Review Letters* 89, 011301 (2002).
- [7] T. Adam et al. (OPERA Collaboration), “Measurement of the neutrino velocity with the OPERA detector in the CNGS beam,” *Journal of High Energy Physics*, 2012:93.
- [8] M. G. Aartsen et al. (IceCube Collaboration), “Evidence for High-Energy Extraterrestrial Neutrinos at the IceCube Detector,” *Science* 342, 1242856 (2013).
- [9] S. Hameroff and R. Penrose, “Consciousness in the universe: A review of the Orch OR theory,” *Physics of Life Reviews* 11, 39–78 (2014). DOI: 10.1016/j.plrev.2013.08.002.

# The Conjugate Interval Principal

The Layered Causality Hypothesis Part IV

Mark Rehl - August 2025

## Abstract

This paper introduces the *Conjugate Interval Principle* (CIP), an extension of the Layered Causality Hypothesis that identifies invariant structures across divergent inertial frames. Building on the Ortiz and Ibarra-Castor formulation of redshift as an energy-based phenomenon, CIP reframes conservation laws in terms of conjugate pairs whose squared-sum forms resemble the spacetime interval. By demonstrating that energy, momentum, angular momentum, and related quantities can all be expressed in interval-like combinations, we show that apparent energy loss in redshifted or causally displaced systems is better understood as redistribution across inaccessible domains. The principle generalizes the earlier concepts of the Jones Threshold and Causal Horizon Law, establishing that non-gravitational coherence persists only while conjugate invariants remain above the fundamental boundary  $E \cdot T = h$ . Beyond this horizon, causal interaction fails, even as total conservation is maintained in interval form. The Conjugate Interval Principle thus provides a unifying language for describing coherence, redshift, and conservation in systems approaching the limits of causal contact.

## Introduction: A Note from the Author

After conceptualizing dark matter as “ordinary matter” existing outside of the observer’s causal window ( $\Delta K_\kappa = \pm 1$ ), I was confronted by a problem: if two systems occupy sufficiently separated frames, wouldn’t they also be moving at enormous speeds relative to one another? Relying on the Lorentz transformation, I first thought of this as straightforward arithmetic — a change of frame must equal a change in velocity.

But then I recalled that time dilation also occurs in the vicinity of black holes and around Earth, caused not by motion but by gravitational gradients. That realization shifted my perspective. I stopped imagining vast flotillas of dark matter streaking past the Milky Way at impossible speeds and instead considered the massive gravitational presence of a substance said to make up nearly 80% of the universe.

If the galaxy and the dark matter surrounding it are not moving relative to one another, then how did they come to occupy such widely separated inertial frames? Perhaps the gravity of the dark matter “captured” the galaxy. But if that were so, wouldn’t the galaxy simply fall into the dark matter’s frame and lose its distinct time rate?

This raised further questions. Did the Big Bang launch multiple Kirk levels at once? Did dark matter accelerate to gain its apparent excess energy? That seemed implausible. Thermodynamics suggests the opposite: smaller systems lose energy more readily than larger ones gain it.

So I began to wonder whether galaxies and dark matter co-evolved. Perhaps galaxies were once embedded pieces of dark matter that lost enough energy to “fall” into a lower part of the Kirk

spectrum. At the time I had not yet invented the Kirk metric as a yardstick, but it was precisely the difficulty of thinking about this problem without such a measure that pushed me toward creating it.

I imagined a galaxy forming within a massive cloud of dark matter. If the emerging galaxy is itself made of dark matter, then to that galaxy the surrounding cloud would appear as “ordinary matter.” The usual story would follow: parts of the cloud attract, angular momentum accumulates, rotation emerges, and non-aligned matter is cleared out. Thus a galaxy takes shape, composed of the same stuff from which it condensed. The problem then became: how did this “dark matter galaxy” lose enough relativistic energy to descend in the Kirk continuum? If it did, its clock would speed up.

Here the reasoning grew more difficult. Every description had to be considered from both perspectives: the galaxy’s and the dark matter’s. I once made myself dizzy mentally jumping between the stationary dark matter cloud and the rotating galaxy.

Redshift was the key. You cannot tell from a redshift what caused it. It could be Doppler, if there is motion, but the galaxy is gravitationally anchored by dark matter from all sides. It could be gravitational, but in a symmetric cloud there is no gradient. How then would I even know if the galaxy were losing energy? Again I circled back: a redshift implies a change in time rate.

Rotation itself does not cause redshift. What about frame dragging, as around a black hole? A galaxy is massive, but not as dense as a black hole. Then the thought struck me: what if the galaxy were trying to drag spacetime around it, but the surrounding dark matter well suppressed that dragging?

I turned to AI tools for help in exploring the equations. At first the AI insisted the math “did not exist,” but I encouraged it to combine relations from frame dragging, spacetime geometry, and large gravitational wells, and to experiment. My guiding question was always the same: does this produce a redshift?

At first the answer was consistently “no.” But the question remained: where does the “suppressed” frame-dragging energy go? Could it slow the galaxy’s rotation, as if through a kind of friction or torque? I began mapping the distribution of energy across disconnected frames. From the dark matter’s perspective, rotation would slow, and the galaxy’s frame, time itself would speed up, while remaining “normal” from its own view.

Eventually there was a breakthrough: an equation involving time and energy produced a redshift. And that redshift, lacking any other viable explanation, must have been caused by a change in relative time rate. At that point I stopped. My goal had been to show only that such a process was possible. If it could produce a redshift in principle, then somewhere in the universe, it must have occurred.

At this stage I was feeling encouraged. I had not yet discovered the Causal Horizon Law, but I did have the Jones Threshold—the fuzzy line where signals disconnect particle by particle. And I now had mathematics suggesting that Frame-Drag Braking could, in principle, generate a redshift while the galaxy was locked in place. Out of curiosity, I googled “redshift without motion” and immediately found a paper by Ortiz and Ibarra-Castor, describing redshift as a strictly energy-based phenomenon [1]. Reading it, I realized it would simplify the work I had just done, and more importantly, explain how energy could be conserved across disconnected frames. Without their paper, I might have continued to treat FDB redshift as an anomalous process, rather than recognizing it as a manifestation of an invariant structure.

Inspired by their formulation, I recast the result into a squared-sum structure:

$$E_{\text{total}}^2 = E_{\text{rot}}^2 + E_{\text{rel}}^2. \quad (1)$$

This interval-like form captured the redistribution of energy across frames. Having seen that the energy balance could be made invariant, I began to wonder: what other conjugate pairs might also be expressed in this way? That question led directly to the Conjugate Interval Principle, the subject of this paper.

## Deriving the Conjugate Interval Principle (CIP)

The Conjugate Interval Principle (CIP) extends the insight that certain physical quantities—when multiplied as conjugate pairs—yield constants that mark coherence thresholds. Unlike the Heisenberg uncertainty relations, which limit the precision of measurement, CIP defines the boundary conditions for causal coherence across diverging relativistic frames. At its core, CIP 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 motivate CIP through an energy-based framework, extending from the work of Ortiz and Ibarra-Castor on generalized redshift [1]. Their equations, which express redshift in terms of energy rather than pure recessional velocity, allow us to identify how energy loss and time dilation combine to threaten causal coherence across frames. (See: Scientific Reports 2024.)

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

– **Mass × Time**

$$mT = \frac{h}{c^2}, \quad (2)$$

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. When this product falls below

$$T = \frac{h}{mc^2}, \quad (3)$$

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

– **Momentum × Position**

$$px = h, \quad (4)$$

where  $p$  is the momentum of the system and  $x$  is the spatial separation between frames or domains. While the quantum-mechanical relations are usually stated as uncertainty bounds [2, 3], CIP reframes the product as a spatial coherence condition across frames: as the separation  $x$  between interacting domains increases, momentum coherence degrades. Beyond the coherence limit defined by CIP, structures become spatially unresolved from each other—ultimately, causally unreachable.

– **Angular Momentum × Angle**

$$L\theta = h, \tag{5}$$

where  $L$  is the angular momentum and  $\theta$  is the angular displacement across frames. When

$$\theta = \frac{h}{L}, \tag{6}$$

gyroscopic coherence fails. This form of CIP suggests that angular momentum may preserve internal coherence during relativistic descent, acting as a stabilizing quantity even as causal contact with external frames diminishes.

– **Energy × Time**

$$ET = h, \tag{7}$$

where  $E$  is the energy of the system and  $T$  is the persistence time as observed across frames. 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 provides a universal threshold:

$$T = \frac{h}{E}. \tag{8}$$

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

These conjugate products form the mathematical backbone of CIP. One of the most consequential is the Energy–Time product, which helps evaluate how coherence degrades across relativistic frames. To explore this further, we gather several specific energy forms that contribute to  $E$ :

**Thermal Energy**

$$E_{\text{th}} = \frac{3}{2}kT_{\text{temp}}, \tag{9}$$

where  $E_{\text{th}}$  is average thermal energy,  $k$  is Boltzmann’s constant, and  $T_{\text{temp}}$  is temperature.

**Kinetic Energy**

$$E_k = \frac{1}{2}mv^2, \tag{10}$$

highlighting how relative motion contributes to observable energy.

**Photon Energy**

$$E_{\text{ph}} = h\nu, \tag{11}$$

where  $E_{\text{ph}}$  is the photon energy and  $\nu$  its frequency; redshift lowers  $\nu$  across domains, reducing observable  $E$ .

**Potential Energy**

$$E_p = mgh_{\text{grav}}, \tag{12}$$

a Newtonian model (useful as an intuition pump) for how energy varies with gravitational position; in curved spacetimes, gravitational redshift provides the relativistic refinement.

### Relativistic Energy

$$E = \gamma mc^2, \quad \gamma = \frac{1}{\sqrt{1 - v^2/c^2}}, \quad (13)$$

where  $m$  is rest mass and  $\gamma$  the Lorentz factor. As  $v$  increases,  $\gamma$  increases; from an external frame's perspective, the *usable* energy for coherent interaction can still drop due to redshift and time dilation. Though velocity-based, this form will reappear 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:

$$\boxed{E \cdot T = h}, \quad (14)$$

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

## Energy Conservation Across Causally Disconnected Frames

We consider two structures that initially share a causal frame. As one descends into a different frame, causal disconnection occurs, leaving the other behind. To examine this process more rigorously, we re-state CIP from two complementary perspectives: (i) classical conservation of energy–momentum, and (ii) the energy-based redshift formalism of Ortiz and Ibarra-Castor.

### Derivation from First Principles

We begin with the standard relativistic energy–momentum relation:

$$E^2 = (pc)^2 + (m_0c^2)^2, \quad (15)$$

where  $E$  is total energy,  $p$  momentum,  $c$  the speed of light, and  $m_0$  rest mass.

In a rotating system with relative motion across frames, energy naturally separates into two components:  $E_{\text{rot}}$  (rotational/internal) and  $E_{\text{rel}}$  (relative to the observer). Assuming conservation of the system's total energetic identity,

$$E_{\text{total}}^2 = E_{\text{rot}}^2 + E_{\text{rel}}^2. \quad (16)$$

This expresses the CIP view: a system's total “interval-like” 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 simple recessional motion [1]. Starting from the quantum energy relation

$$E = hf, \quad (17)$$

a change in observed frequency implies a change in measurable energy. Define the observed redshift

$$z = \frac{f_f - f_o}{f_o}, \quad (18)$$

where  $f_f$  is the emission-frame frequency and  $f_o$  the observer-frame frequency.

In this framework, the observed redshift can be understood as redistribution of energy among components, preserving the same squared-sum relation found in Eq. (16). Thus, CIP is recoverable from both classical conservation and energy-based redshift: redshift reflects internal structural rebalancing, not necessarily motion.

## Conjugate Interval Principle (CIP): Generalized Form

Based on the energy-based redshift formulation, CIP reinterprets “energy loss” as redistribution of conserved quantities into an inaccessible causal domain. Where standard equations account only for observables in a single inertial frame, CIP posits that totals remain conserved via interval-like structures even when parts of the system become causally displaced. The squared-sum pattern mirrors the spacetime interval:

<ul style="list-style-type: none"> <li>• <b>Total Energy:</b> <math>E_{\text{total}}^2 = E_{\text{rot}}^2 + E_{\text{rel}}^2</math></li> <li>• <b>Momentum:</b> <math>p_{\text{total}}^2 = p_{\text{local}}^2 + p_{\text{rel}}^2</math></li> <li>• <b>Angular Momentum:</b> <math>L_{\text{total}}^2 = L_{\text{orbit}}^2 + L_{\text{rel}}^2</math></li> </ul>	<ul style="list-style-type: none"> <li>• <b>Kinetic:</b> <math>E_{\text{kin}}^2 = E_{\text{linear}}^2 + E_{\text{rel}}^2</math></li> <li>• <b>Thermal:</b> <math>E_{\text{thermal}}^2 = E_{\text{temp}}^2 + E_{\text{rel}}^2</math></li> <li>• <b>Photon:</b> <math>E_{\text{photon}}^2 = E_{\text{freq}}^2 + E_{\text{rel}}^2</math></li> <li>• <b>Potential:</b> <math>E_{\text{pot}}^2 = E_{\text{field}}^2 + E_{\text{rel}}^2</math></li> </ul>
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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. What seems like loss is, in this view, a geometric redistribution across frames.

The coherence of this redistribution is not unbounded. As  $E$  drops while the duration  $T$  required for influence grows, their product approaches a universal cutoff:

$$\boxed{E \cdot T = h} \quad (19)$$

We refer to this as the *Causal Horizon Law*: a definitive limit beyond which non-gravitational interaction fails. Signals may continue, but no coherent decoding is possible past the horizon.

## Redshift Without Motion

Redshift is typically interpreted through the lens of Doppler recession: systems move apart, wavelengths stretch, and frequencies decrease. Yet this conventional view overlooks the fact that redshift can also arise in the absence of motion. In the context of layered causality, the phenomenon is better understood as an outcome of energy redistribution across frames.

Consider two systems gravitationally bound within a common dark matter potential. Neither system is receding from the other in a translational sense, yet signals exchanged between them are observed to be redshifted. The effect cannot be attributed to Doppler motion, and in a symmetric potential well no net gravitational gradient is available to explain it either. What remains is the change in relative time rate between frames.

Formally, the redshift parameter is given by:

$$z = \frac{f_e - f_o}{f_o} \quad (20)$$

where  $f_e$  is the emission frequency and  $f_o$  the observed frequency. This relation holds without reference to velocity. In the Ortiz and Ibarra-Castor framework [1],  $z$  expresses the difference in available energy between frames:

$$E = hf \quad (21)$$

so that a change in  $f$  directly implies a change in measurable  $E$ .

Within the Conjugate Interval Principle, this is interpreted as redistribution of energy into an inaccessible domain rather than loss. The squared-sum structure preserves conservation:

$$E_{\text{total}}^2 = E_{\text{rot}}^2 + E_{\text{rel}}^2 \quad (22)$$

Even as one component becomes unavailable, the total remains invariant. Redshift therefore signals not motion but causal separation: a frame has shifted in such a way that part of the system’s conserved structure is now inaccessible to the observer.

This perspective reframes redshift as a universal marker of divergence across frames. It is not evidence of relative velocity per se, but of the breakdown of synchronization between clocks. A system can remain gravitationally anchored and spatially coincident with another, yet still produce redshift if their inertial frames diverge. In this sense, “redshift without motion” is not anomalous—it is the natural expression of interval invariance in the layered causal structure.

## References

- [1] A. Ortiz & A. Ibarra-Castor, “Generalized redshift formula through an energy-based framework,” *Scientific Reports* **14**, 56188 (2024). DOI: 10.1038/s41598-024-56188-1.
- [2] W. Heisenberg, “Über den anschaulichen Inhalt der quantentheoretischen Kinematik und Mechanik,” *Z. Phys.* **43**, 172–198 (1927).
- [3] H. P. Robertson, “The Uncertainty Principle,” *Phys. Rev.* **34**, 163–164 (1929).

# Frame-Drag Braking

The Layered Causality Hypothesis Part V

Mark Rehl - August 2025

## Abstract

This paper introduces the concept of *Frame-Drag Braking* (FDB), a proposed mechanism by which galaxies may descend across the Kirk continuum into faster time-rate frames. Building on the Conjugate Interval Principle and the boundary relation  $E \cdot T = h$ , FDB describes how a rotating system embedded in a massive dark matter potential may experience resistance to its frame-dragging influence. This resistance suppresses the expression of rotational energy, producing redshift not through recession but through the redistribution of energy across causally separated domains[1]. We argue that such redshift without motion is a natural consequence of layered causality and that the braking effect provides a plausible channel by which galaxies lose energy and descend while remaining gravitationally bound. The framework situates FDB as the dynamical counterpart to the Causal Horizon Law, offering a testable pathway for understanding how structure evolves near the limits of causal coherence.

## Introduction: A Note from the Author

On the day I worked out what became the Conjugate Interval Principle, I was doing repair work, walking around a large table with my iPhone propped up on its stand. I had been testing the interval-like form on different conjugate pairs, one at a time, letting the AI on my phone run through them while I multitasked. Only a few nights earlier I had used it in a different way, combining equations in search of a mechanism by which an emerging dark matter galaxy might lose enough energy to descend into a lower-energy, faster time-rate frame. I felt I had found something plausible, enough at least to take the idea seriously.

Something interesting happened when I asked the AI to test Time and Energy as a conjugate pair. It replied: “Yes, but only in a particular ratio of time and energy.” At first I thought this meant failure. But then I asked: “When we found the result we were looking for the other night, were the energy and time in that ratio?” The answer came back: “Yes.”

“Then I believe we may have found a constant,” I said. Wanting to continue my physical work, I told it: “See if you can boil it down to its essence.” The answer returned was simply:

$$E \cdot T = h \tag{1}$$

Though deceptively simple, I recognized immediately that this must be the reason non-gravitational interactions cease at the boundary of  $K_\kappa = 1$ . It echoed Planck’s relation, but with a different significance: not a quantum of action, but a boundary of coherence[2,3]. The fuzzy Jones Threshold had been replaced by something more concrete. I felt gratitude toward the Ortiz and Ibarra-Castor

work, whose energy-based formulation of redshift had led me here[1]. This was the line where interactions between frames stop.

I paused and asked the AI if this relation already existed under another name. It replied that it did not, though it mirrored the uncertainty principle, and suggested I record a time-stamped copy. I followed its recommendation. Such is the roller-coaster of inquiry: one moment unsure, the next feeling like I could see the whole town from a higher perch.

Although this equation provided the boundary, it did not tell me the timescale of descent. Every galaxy is different, and the uncertainties in the variables make the margins so large that estimates are nearly useless. For now, the process must be treated as a starting point rather than a final word. What matters is that some mechanism must exist to enforce descent in the Kirk continuum, if it occurs at all.

This paper develops one such mechanism: *Frame-Drag Braking*.

## Frame-Drag Braking and the Descent from Dark Matter

*Note: A distinct but conceptually adjacent use of “frame-drag braking” was introduced in black hole spin-reduction contexts by Penrose [4]. The term is naturally descriptive, and the uses are independent.*

Frame-Drag Braking (FDB) was originally conceived to resolve a paradox: if dark matter exists in a faster-moving (through space) relativistic frame, how can a slower-moving galaxy remain gravitationally bound to it? This led to the insight that galaxies and their surrounding dark matter may have co-formed within the same inertial frame and later diverged. The challenge then became to identify the mechanism driving this frame separation.

Rotation alone could not produce the necessary redshift. The hypothesis turned to Frame-Drag Braking: the idea that a galaxy’s attempt to rotate the surrounding spacetime is met with resistance from a massive, symmetric envelope of dark matter. This resistance, in turn, initiates a relativistic descent in Kirk coordinates.

Unlike traditional acceleration, which causes separation in frame space (as in the Twin Paradox), frame-drag braking acts as a gravitationally bound resistance to rotation that induces a descent in relativistic frame position. It is a mechanism for monotonic descent in Kirk space—a process by which a system loses relativistic energy and accelerates in proper time relative to the realm of familiar visible galaxies.

## Mathematical Closure for Frame-Drag Braking

Let the spacetime be stationary and axisymmetric, with two Killing vectors:

$$\xi^a = \partial_t \quad (\text{time symmetry}), \quad \psi^a = \partial_\phi \quad (\text{rotation symmetry}).$$

From these symmetries, we define conserved quantities:

$$E \equiv -p_a \xi^a, \quad L \equiv p_a \psi^a \tag{2}$$

where  $E$  is the Killing energy and  $L$  the Killing angular momentum.

When an external torque is applied (modeled by a four-force  $f_a$ ), the rates of change are:

$$\dot{E} = f_a \xi^a, \quad \dot{L} = f_a \psi^a. \quad (3)$$

Assuming a dissipative torque that drives the system toward co-rotation with the local frame-drag rate  $\omega$ , we posit[4]:

$$\dot{L} = -\alpha (\Omega - \omega), \quad \alpha > 0, \quad (4)$$

where  $\Omega$  is the orbital angular velocity.

*Note: For an extended dark matter distribution, perfect co-rotation is unlikely to occur globally; only the locally coupled halo may approach  $\omega$ , leaving residual braking from more distant mass.*

Given the angular velocity–energy relation for circular orbits at fixed  $r$ ,

$$dE = \Omega dL \quad \Rightarrow \quad \dot{E} = \Omega \dot{L} = -\alpha \Omega (\Omega - \omega), \quad (5)$$

as long as  $\Omega(\Omega - \omega) \geq 0$ , we have  $\dot{E} \leq 0$ : energy decreases monotonically.

We write the Killing energy as:

$$E = \gamma mc^2 + \Phi, \quad (6)$$

where  $\Phi$  is the gravitational potential. Differentiating,

$$\frac{dE}{dt} = \frac{\dot{E}}{\gamma} \quad \Rightarrow \quad \dot{\gamma} = \frac{1}{mc^2} \frac{dE}{dt} < 0. \quad (7)$$

Assuming the Kirk coordinate  $K_\kappa = \log \gamma$ , it follows:

$$\dot{K}_\kappa < 0. \quad (8)$$

Thus, Frame-Drag Braking corresponds to a descent in Kirk space under external torque—a quantitatively defined process.

## Asymmetric Descent and One-Sided Redshift

Signals encode the *emitter's* clock state at the moment of emission. If a source has *descended* by a frame gap  $\Delta K$  between some shared past and the emission event, its intrinsic processes run slower by a factor

$$R = \frac{1}{1+z}. \quad (9)$$

The received light is therefore redshifted by

$$1+z = \frac{1}{R}. \quad (10)$$

No reciprocity is implied: observers do not generically see each other equally redshifted. What we measure is the other system's descent history along our past light-cone, not a symmetric, simultaneity-based comparison of clocks.

A convenient phenomenology is

$$D(z) = \frac{c}{\alpha} \ln(1+z), \quad D_L = (1+z)D, \quad (11)$$

where  $\alpha$  is an effective descent-rate parameter. At low  $z$ ,

$$D \simeq \frac{c}{\alpha} z, \quad (12)$$

so that  $\alpha$  plays the same empirical role that  $H_0$  does in a Hubble plot, while remaining agnostic about spatial expansion.

## Neutrinos and Galaxies: What I Don't Know

Even after all the structure laid out so far, much remains uncertain. Neutrinos, for example, seem almost invisible to ordinary gravity. A planet's mass scarcely bends their path, while galaxies—even after descending across a frame interval  $\Delta K$ —still appear to be gravitationally bound. Why one kind of system loses grip while another remains coherent is not yet clear. This gap is a reminder that even within a speculative framework, there are limits to what I can claim to know.

One point, however, is firm: unlike expansion, descent is not symmetric. As already shown in Eqs. (17)–(19), signals carry the emitter's clock state, so two galaxies descending together would not, in principle, both see each other as redshifted. If their clocks were perfectly synchronized and we had instantaneous knowledge, no offset would appear. But knowledge is never instantaneous—light takes time to travel. The photons arriving at Galaxy A from Galaxy B were emitted when B's clock was slower, and the same is true in reverse. Thus, even galaxies descending in sync perceive each other's older light as redshifted.

Plotted against redshift, this mechanism shadows the expansion model for much of cosmic history. Only at higher redshifts do the interpretations diverge, with expansion gaining explanatory power. But in those very regimes, the time-rate of galaxies would appear extremely slow from our frame, and that slowness must be factored into any analysis. The same is true for cosmological signals such as BAO peaks: as with all audio phenomena, a slower time-rate shifts the beat downward, making the universal signal bassier at high redshift.

This leaves open the possibility that descent does not replace expansion, but may instead mimic acceleration—the very signal attributed to dark energy. Whether this is a mirage or a clue remains to be tested. For now, I leave the formal argument here. What follows in Part VI is speculation, where the questions broaden: how far descent might go, how redshift illusions might be layered onto expansion, and how hypotheses tend to ride upon one another. The Big Bang framework has shown how a single idea can seed an entire explanatory edifice; in the same way, frame-drag descent may branch into interpretations beyond what I can presently anticipate.

## References

- [1] A. Ortiz & A. Ibarra-Castor, “Generalized redshift formula through an energy-based framework,” *Scientific Reports* **14**, 56188 (2024). DOI: 10.1038/s41598-024-56188-1.
- [2] W. Heisenberg, “Über den anschaulichen Inhalt der quantentheoretischen Kinematik und Mechanik,” *Z. Phys.* **43**, 172–198 (1927).
- [3] H. P. Robertson, “The Uncertainty Principle,” *Phys. Rev.* **34**, 163–164 (1929).
- [4] R. Penrose, “Gravitational collapse: the role of general relativity,” *Rivista del Nuovo Cimento* Numero Speciale I, 252–276 (1969).

# Speculations and Ideas

The Layered Causality Hypothesis Part VI

Mark Rehl – August 2025

## Introduction: A Note from the Author

The primary purpose of this paper is to unify the previous five parts of the Layered Causality Hypothesis, so they may be bound as a single body of work. This will be done in three ways: by providing testable predictions that may one day support or falsify its claims, by collecting ideas and questions that remain speculative, and by assembling in one place all citations and numbered equations from the earlier papers.

I want to assure the reader that, even when some of the arguments may seem unconventional—or even controversial—that was never my intent. Quite the opposite: most of what appears here is a respectful reinterpretation of well-established facts and principles. The single case I have tried to make is that there must be a limit to the number of inertial frames with which we can interact, and that dark matter may simply be ordinary matter occupying frames beyond our causal reach. To follow that idea where it led required questioning some accepted wisdom, but the path was always guided by logic, mathematics, and observation.

My hope is that these ideas will be judged on their own merits, and not on externalities such as who I am, or why I dare to raise them. With the help of an AI assistant, and through a great deal of effort, I was able to write this collection of papers in less than five months. In truth, though, it represents more than forty years of fascination with physics, most of that spent quietly in personal study. Where others may have counted sheep to fall asleep, I tried to drift off by thinking about gravity. You should try it sometime—it often works. And if it doesn't, well, sometimes just listening to me talk about it does the trick.

What follows is not a set of conclusions, but a sketch of possibilities. The formal structure of Frame-Drag Braking was developed in the preceding sections, and it may provide a useful foundation. Here, however, I turn to what may be downstream consequences of that mechanism. These thoughts are more fragile, less defended, but worth airing, because hypotheses grow by being tested against the unexpected as much as by explaining the expected.

The Big Bang framework shows how one idea can generate an entire scaffolding of related interpretations: expansion, nucleosynthesis, the CMB, dark matter, and dark energy all extend from that root. I end with a demonstration of that phenomenon called *“If the Big Bang Never Happened.”* Every day I see something new calling the Big Bang into question, mostly because of surprising JWST observations[2] I thought it would be interesting to list what would fall with it.

The ideas here may ride in a similar way on Frame-Drag Braking, branching into their own network of interpretations, whether or not they thrive or endure. Nothing is immune to new data.

## Time as a Compressed Spring

In the Layered Causality framework, slowed time is not a passive byproduct of motion or mass; it is a *storage mode for surplus energy*. When a system attempts to inject more usable energy into its state (via thrust, spin-up, gravitational infall, or thermal loading), spacetime does not allow unbounded expression as velocity. Instead, the excess is reallocated into curvature and time dilation so that causal structure remains coherent.

*For every action there is an equal and opposite reaction, which is space’s way of saying “no thanks”—I don’t want that energy. Since it can’t give it back as rocket fuel, it gives it back as acceleration and time dilation.*

A simple way to see the bookkeeping is with the Causal Horizon product. Let  $E$  denote the *usable* energy available for coherent interaction across a frame gap and  $T$  the corresponding persistence time. Near the causal boundary, their product is constrained,

$$ET \gtrsim h, \tag{1}$$

so small changes satisfy

$$\delta(ET) = T \delta E + E \delta T \gtrsim 0 \Rightarrow \delta T \gtrsim -\frac{T}{E} \delta E. \tag{2}$$

If a system pushes  $\delta E > 0$  (more *attempted* usable energy), the reaction is  $\delta T > 0$  (slower proper time) unless some of that load is off-ramped into curvature or other channels. In this sense, time dilation is a *pressure release valve* that keeps  $E \cdot T \gtrsim h$  from being violated.

**Where the surplus goes (reaction channels).** Spacetime “says no” to excess usable energy by redistributing it into:

- **Curvature (gravity):** Mass–energy sources curve spacetime; deeper wells raise  $T$  locally (gravitational time dilation). The inertial effect of curvature shows up as free-fall acceleration rather than ever-increasing usable  $E$ .
- **Time dilation (kinematic):** Boosting  $\gamma$  (e.g., by thrust) increases proper-time stretch, converting would-be kinetic expression into slower clocks as seen by other frames.
- **Mass-loading / binding: Why matter soaks the first Kirks (storage -separation).** Define the Kirk coordinate by  $K = \frac{\ln \gamma}{\ln 707}$  so that  $K = 1$  corresponds to  $\gamma = 707$ . For a body of mass  $m$ , the energy needed to kinematically raise it to a given  $K$  is

$$E_{\text{boost}}(K) = (\gamma - 1) mc^2 = (707^K - 1) mc^2. \tag{3}$$

The *same* energy, if spent on mass-loading instead, would create additional rest mass

$$\Delta m = \frac{E_{\text{boost}}}{c^2} = (707^K - 1) m. \tag{4}$$

Thus, to push a single mass  $m$  up to:

$$\begin{aligned}
 K = 1 : \quad & E_{\text{boost}} \approx 706 mc^2 && \Rightarrow \text{could create } \Delta m \approx 706 m, \\
 K = 2 : \quad & E_{\text{boost}} \approx 707^2 - 1 mc^2 \approx 5.0 \times 10^5 mc^2 && \Rightarrow \Delta m \approx 5.0 \times 10^5 m, \\
 K = 3 : \quad & E_{\text{boost}} \approx 707^3 - 1 mc^2 \approx 3.53 \times 10^8 mc^2 && \Rightarrow \Delta m \approx 3.53 \times 10^8 m.
 \end{aligned}$$

In other words, the energy required to *separate a frame* by even one Kirk could instead create hundreds of copies of the original mass; by two Kirks, half a million copies; by three Kirks, hundreds of millions.

**Takeaway (heuristic).** In any environment where mass creation/binding channels exist, the universe will overwhelmingly “pay” surplus energy into *matter* long before it “pays” for large  $K$ -separation. Practically, *matter acts like the first several Kirks of energy storage*: it soaks the surplus in rest mass (and binding) rather than pushing systems to extreme  $\gamma$ . Only after mass-loading avenues saturate (or are forbidden) does persistent frame separation (large  $K$ ) become entropically/economically favorable.

- **Inertial back-reaction (acceleration):** Attempts to drag spacetime (e.g., spin-up inside a massive, symmetric well) meet resistance. The work done against that resistance shows up as reduced  $E_{\text{rot}}$  and increased  $T$  or curvature—i.e., *frame-drag braking*.

If all galaxies are losing usable energy through this same mechanism, then the reallocation must appear on a universal scale. Unlike a boat displacing water upward, where the energy pushes against a surrounding medium, the universe has no “up” to rise into. If energy cannot be absorbed inward, the only remaining direction is outward. What we interpret as expansion energy may be nothing more than the collective back-reaction of every galaxy’s descent, leaking into the large-scale fabric of time and space.

**A unified bookkeeping response.** In practice, what appear to us as separate mechanisms—gravity, time dilation, matter, and acceleration—are simply different expressions of the same causal bookkeeping. Each is a way of reallocating surplus energy so that the boundary  $E \cdot T \gtrsim h$  is never violated.

**Link to interval bookkeeping.** In the interval view used earlier, the total energetic identity remains conserved while the *partition* shifts:

$$E_{\text{total}}^2 = E_{\text{rot}}^2 + E_{\text{rel}}^2, \tag{5}$$

so braking a rotor inside a massive well reduces  $E_{\text{rot}}$  and reallocates into  $E_{\text{rel}}$  and/or curvature, with the *perceived* usable  $E$  across frames dropping as  $T$  rises. In short: when a system tries to spend more usable energy, spacetime *stores* the overage as curvature and slower time—the compressed spring of causality.

## 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 is not a modern revision, it has been part of the story from the beginning. The Lorentz Transformation does not create this truth; it simply reveals it[1]. 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[1]. We seem to have a psychological need for the universe to conform to our clock. But the universe has no obligation to comply.

Why, then, do we call it 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 did the logical thing—we worked backwards. We traced the trajectories to their point of origin and reconstructed 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—despite already knowing time is frame-dependent—was folded into a single timeline. The Layered Causality Hypothesis did not set out to dispute this narrative. It set out only to explain dark matter. But telling that story in full meant checking every step. And eventually, some of those early dominos began to wobble.

## An Invariant Calendar for All Frames

Human history already demonstrates the power of assigning one reference point as the pivot of chronology. We speak of years *B.C.* and *A.D.*, measured relative to a single cultural event. Physics lacks such a universal marker across frames. Each inertial band ticks to its own rate, and so far there is no agreed-upon post in the ground that everyone could use.

Since this is speculative territory, I propose one. With due humility—and a wink—I claim it as my purview to name the marker after one of the great creative voices of our age: Peter Gabriel. At the moment of his eventual death (which I sincerely hope will not come sooner than necessary), let us define a universal epoch. All times would then be measured as either *BPG* (Before Peter Gabriel) or *APG* (After Peter Gabriel).

The essential idea is that this PG marker is not just a calendar trick, but a *frame-invariant post*. The zero frame is defined as our own, and every other frame knows its Kirk value  $K_\kappa$ . With that, the conversion is straightforward: if an event occurs  $t$  years APG in the zero frame, then a frame at  $+0.5 K_\kappa$  would record it as  $t' = b^{-0.5} t$  years APG, with  $b = 707$  the base of the Kirk definition. Thus the phrase “*It happened at 125 APG*” has a definite meaning in every frame. Each community simply translates according to its known  $K_\kappa$ .

This proposal is deliberately playful, but it makes a point. A physics that truly acknowledges the relativity of time ought to define at least one invariant calendar post. The PG epoch is no less arbitrary than our existing human conventions, but it is transparent about what it measures: a shared causal marker whose rate can be consistently transformed across frames. Whether or not anyone adopts it, the idea illustrates that timekeeping, like physics itself, may need both humility and humor to stay honest.

## The End of the Big Bang

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

- there is no cosmic acceleration,
- the universe does not have a singular age,
- spacetime cannot expand faster than light, only appear to do so across disconnected causal domains,
- warp drives are likely impossible, since space itself cannot be manipulated to exceed  $c$ , even “indirectly,”
- dark energy is not a force, but a misreading of redshifts,
- 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, possibly infinite past[3] ,
- and we must reimagine the visible cosmos not as the origin, but as a structured expression of something larger, faster, and more causally distant.

## Photons, Memory, and Media

Every photon is a kind of memory. It carries the record of an event forward, indifferent to whether anyone notices. When it strikes an eye, or a telescope, or the dust of a nebula, the information it carries is either absorbed or transformed, but never negated. In that sense, light is the universe’s first historian.

What we call “observation” is really just interception of this ongoing archive. A star is not shining for us, it is writing its own diary, one photon at a time, into the future. We step into the path of that diary and take what we can. From this perspective, information is something we borrow from from our environment. Light preserves, matter stores, and minds recall; It is all parts of one chain. Even “memories” are frame-dependent. A photon’s story may stretch or compress depending on the clock of the frame it passes into. What we preserve is always partial: not a master record of reality, but the version of memory that our causal layer allows.

## References

- [1] Rindler, W. *Relativity: Special, General, and Cosmological*, 2nd ed., Oxford University Press (2006).
- [2] Gardner, J. P.; Mather, J. C.; Clampin, M.; Doyon, R.; et al. “The James Webb Space Telescope,” *Space Science Reviews* **123**, 485–606 (2006). DOI: 10.1007/s11214-006-8315-7.
- [3] Planck Collaboration. “Planck 2018 results. VI. Cosmological parameters,” *Astronomy & Astrophysics* **641**, A6 (2020). DOI: 10.1051/0004-6361/201833910.

# Testable Predictions and Empirical Implications

The Layered Causality Hypothesis Part VII

Mark Rehl – August 2025

## 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 (cf. JADES-GS-z14-0[1]).

*Test:* Compare lensing signatures of  $z \sim 12+$  objects with the absence of corresponding visible/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  $\Lambda$ CDM expansion[2, 3]. If redshift partly reflects frame divergence, angular size could appear larger than expected.

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

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

*Prediction:* Quantum coherence (e.g., entanglement/phase alignment) will not persist across frame separation corresponding to  $z \approx 0.58$  ( $v \sim 0.8c$ )[4, 5].

*Test:* Attempt long-distance entanglement over relativistic velocity separations; loss of coherence near that boundary would support the LCH inter-frame decoherence claim.

## 4. Asymmetry in Clock-Rate Perception (Reciprocal Redshift)

*Prediction:* Observers in two causally separated frames perceive opposite effects on the other's clock: one appears slowed, the other accelerated[6].

*Test:* Analyze precision timekeeping on high-velocity probes as they approach relativistic separation for asymmetric drift signatures.

## 5. Cosmic Microwave Background (CMB) Reinterpretation

*Prediction:* The CMB may show small directional anisotropies or spectral distortions correlated with known large-scale/dark-matter structure, consistent with causal leakage rather than a singular-origin afterglow[3].

*Test:* Cross-correlate CMB anomaly maps with large-scale structure catalogs.

## 6. RIP Conservation Across Frame Descent

*Prediction:* Galaxies losing angular momentum exhibit proportional increases in external redshift/clock-rate shift, preserving the interval

$$E_{\text{total}}^2 = E_{\text{rot}}^2 + E_{\text{rel}}^2.$$

*Test:* Track declining-spin systems for correlated redshift/temporal-shift trends.

## 7. Time-Perception Compression in Higher Frames

*Prediction:* Higher causal frames perceive our history as compressed, with reduced observable event complexity per unit of their proper time.

*Test:* Simulate observations from elevated frames and analyze entropy/complexity rates.

## 8. Visibility Loss Before the Schwarzschild Radius

*Prediction:* From a stationary frame, emission from matter approaching a black hole fades  $\sim 0.03 K_\kappa$  before the Causal Horizon; visibility loss precedes the Schwarzschild surface[7].

*Test:* Compare dimming profiles and inferred redshift with the final  $0.03 K_\kappa$  approach to the Causal Horizon.

## 9. High- $z$ BAO and Variable-Star Clock Rates (ELT/SKAO)

*Prediction:* If redshift partly reflects descent through frame space rather than pure geometric expansion, then very high- $z$  structures ( $z > 10$ ) will show anomalously slow internal clocks:

- BAO peaks shift to lower frequencies (“bassier”) than  $\Lambda$ CDM expectations[2].
- Variable stars (Cepheids, RR Lyrae) at high- $z$  exhibit longer pulsation periods than expansion-only scaling predicts.

*Test:* ELT will directly resolve high- $z$  stellar periods[8]; SKAO will map BAO with high precision[9]. Concordance with  $\Lambda$ CDM favors expansion-only redshift; systematic downward BAO frequencies or elongated periods support a frame-descent contribution.

## References

- [1] Curtis-Lake, E. *et al.* (JADES Collaboration), “Spectroscopic confirmation of galaxies at redshifts up to 14 with JWST/NIRSpec,” *Nature Astronomy* **7**, 622–632 (2023). DOI: 10.1038/s41550-023-01924-9.
- [2] Eisenstein, D. J. *et al.*, “Detection of the Baryon Acoustic Peak in the Large-Scale Correlation Function of SDSS Luminous Red Galaxies,” *Astrophysical Journal* **633**, 560–574 (2005).
- [3] Planck Collaboration, “Planck 2018 results. VI. Cosmological parameters,” *Astronomy & Astrophysics* **641**, A6 (2020). DOI: 10.1051/0004-6361/201833910.
- [4] Heisenberg, W., “Über den anschaulichen Inhalt der quantentheoretischen Kinematik und Mechanik,” *Z. Phys.* **43**, 172–198 (1927).
- [5] Robertson, H. P., “The Uncertainty Principle,” *Phys. Rev.* **34**, 163–164 (1929).
- [6] Rindler, W., *Relativity: Special, General, and Cosmological*, Oxford University Press (2006).
- [7] Schwarzschild, K., “Über das Gravitationsfeld eines Massenpunktes,” *Sitzungsberichte der Königlich Preussischen Akademie der Wissenschaften* (1916).
- [8] European Southern Observatory (ESO), “The Extremely Large Telescope (ELT): World’s Biggest Eye on the Sky,” (accessed 2025). URL: <https://elt.eso.org/>.
- [9] Square Kilometre Array Observatory (SKAO), “SKAO Science Goals and Key Projects,” (accessed 2025). URL: <https://www.skao.int/en/science>.