Relativistic Uncertainty Principle Makes Redshift Diminish Observability: Cosmic Acceleration Is Illusion

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Abstract

Mainstream cosmology proclaims the cosmic expansion is in acceleration, by "dark energy." This paper nullifies the acceleration—by reinterpreting cosmological observation data via a hidden relativistic law, *free* of parameter fitting. Per the law, the fundamental particle's blue- or redshift diminishes the particle's observation probability, namely, the observability of the event that emitted the particle. The event's observability roots in the observable event-size, that is, as the Heisenberg uncertainty principle implies, the multiplicative product (measured in $\hbar$) of conjugate uncertainties. The observability reflects a) *relativistic event-size contraction* and, equivalently, b) the degree of *resonance in length scale*, between the event and the observer. Though each varying with relativity, redshift and observability covary into the law, per the principle of relativity—and per the *relativistic* uncertainty principle herein derived. The law holds in particle physics, evaporates "dark energy," and appears to dissolve two other cosmological enigmas, all without numerical tweak. The law is lab-testable.

I. Introduction

Redshift z is $(\lambda/\lambda_0)-1$, where λ is the observed wavelength at the observer, and λ_0 the proper wavelength at the wave-emitting event. Unless otherwise stated in terminology, redshift z: $(-1, \infty)$ covers blueshift z: $(-1, 0)$, and the cosmological redshift is positive. The paper shows, as a law, how the redshift itself compromises the observability—namely, the observation *probability*—of an event, either fundamental or composite. The law dismisses "cosmic acceleration" [1–3] and returns the cosmos to the critical expansion [4,5], to within observational uncertainty.

The most celebrated "evidence of cosmic acceleration" has been Type Ia supernovae's 'luminosity-distance vs. redshift' [1–3]—as interpreted by the cosmological model [4,6] that introduces the dark-energy density Ω_Λ. Other "supporting evidence," such as from the cosmic microwave background (CMB) [7], etc. [8], for correlation, also roots in the same parameter-space featuring Ω_Λ. While welcoming Ω_Λ's seeming theoretical convenience, we are "solving" the mystery by creating another; moreover, phenomenological correlation unnecessarily implies physical causation.

The event observability $\tilde{\phi}$: $[0, 1]$ is the *effectiveness* of the event's luminosity in emission of any elementary particle(s), and the effectiveness is independent of the luminosity distance.

As a preview, Fig. 1 depicts the law on how $\tilde{\phi}$ decreases from 100% with no blue- or redshift ($z = 0$), down to zero at the extreme of blueshift (z '=' -1) or redshift (z '=' ∞). For instance, in the (quasi) 'universe of special relativity (SR),' the luminosity of a 100-W lightbulb moving away from or toward us at half the speed of light 'dims'—but *not* in itself—to of a 60-W stationary to us. Likewise, in the universe of general relativity (GR), a star 'dims'—not in itself—to 47%, as its redshift z reaches 1.

In short, the compromise on $\tilde{\phi}$ reflects the mismatch between λ and λ_0. The law agrees with the common knowledge that λ '=' 0 and ∞ be unobservable, as the blackbody radiation has implied. By contrast, behind the "cosmic acceleration," the subliminal belief that $\tilde{\phi}$ is always 100% (i.e., z- independent) fails the sanity check.

We coin such variation as the law of relativistic observability compromise (ROC). The *dimming* effect deceives us to believe the cosmic objects 'were' *farther* than expected, "owing to acceleration."

The law is counterintuitive; in daily life, we see *light* predominantly from *events* moving orders-of-magnitude slower than light, causing no discernible loss of observability. For instance, even in the Large Hadron Collider (LHC) [9], the light-emitting collision *events* (between near–light-speed mass particles) are mostly speedless; even in the synchrotron, the light-emitting events are tangent to the electrons' circulating orbit and 'fixed' to the lab (though the electron speed is relativistic).

The law is imperative; in measuring wavelength, we have neither resolution for zero nor capacity for infinity, that is, cannot observe the extremes of blue- and redshift.

In GR, the ratio λ/λ_0 equals L_{OB}/L_{PP}, where a) L_{OB} is the *event's observed* length-scale (in the event-observer direction), measured at the observer, and b) L_{PP} the *event's proper* length-scale, measured at the event—and virtual-equivalently at the observer, thanks to the principle of relativity (PoR) [10–12]. Per the 'new' law, with redshift z being $(L_{OB}/L_{PP})-1$, we will show event observability $\tilde{\phi}$ reflects the degree of *resonance in length-scale*, between a') the *proper-observer*–scaled event and b') the *proper-event*–scaled observer (i.e., the '*proper-observer*–scaled observer,' thanks to the PoR).

The argument begins with **Postulate 0:** *In quantum mechanics (QM), event observability is the probability of occurrence of the structureless event-to-observer vectoring particle (namely, elementary particle) at the generalized observer* (see Section II). *Congruently, event observability is the observable event-fraction, that is, the ratio of the observable event-size (manifested by the particle) over the proper event-size.* The default unit for event-sizes is $\hbar$, for being *impartial* between any pair of conjugate observables. In 'classical' SR and QM, the observable event-size σ_{OB} equals $\Delta(r)\Delta(p_r)$ —i.e., the product of a) uncertainty in position increment r and b) that in momentum p_r. Likewise, the proper event-size σ_{PP} equals $\Delta(\tau)\Delta(m_0)$ —i.e., of a') uncertainty in proper-time increment τ and b') that in rest-mass m_0. At face value, the event-fraction σ_{OB}/σ_{PP} $(\equiv \bar{\phi})$ becomes the event observability.

Introduced herein as a scaffold, stochastic SR modifies the event observability (to $\tilde{\phi}$, in notation) by asserting the speed of light shows not only a) an a priori constant expectation-value shared by all event-observer pairs but further b) an uncertainty inherent

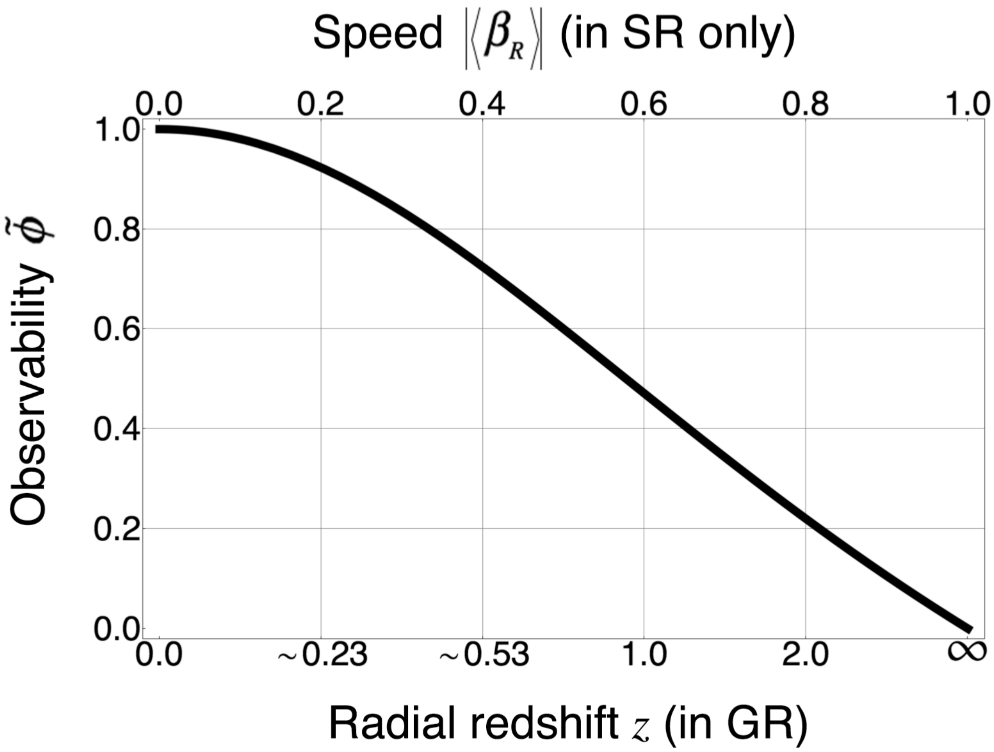


Fig 1. Blue- and redshift diminish event observability $\tilde{\phi}$.

Independent of the (event-to-observer) luminosity distance, $\tilde{\phi}$ is the *effectiveness* of the event's luminosity, in emission of any elementary particle(s). (A) $\tilde{\phi}(|\langle\beta_R\rangle|)$ (to the upper abscissa), where $|\langle\beta_R\rangle|$ is the radial speed of the event in (stochastic) special relativity (SR), per Eq. (6). (B) $\tilde{\phi}(z)$, where $z: (0, \infty)$ is the radial redshift of the event's emission in general relativity (GR), per Eq. (12). For radial *blue*shift $z: (-1, 0)$, $\tilde{\phi}(z)$ shows the same curve, but left-right reversed.

and specific to each event-observer pair. The speed of light must manifest its statistical nature in observation.

It is the definition of observability, along with the uncertainty in the speed of light, that unveils the law of ROC, in stochastic SR. Second, it is the principle of relativity that sublimes the law into an integral aspect of GR.

II. Event Network

In QM, we have events and observers; 'event' refers to a fundamental happening (e.g., an interactional collision between fundamental particles), whereas 'observer' to an observation *event* (still an event)—which constitutes a *generalized* observer (as opposed to a conscious observer, such as you or me). On top of its usual context in relativity, 'observation' now emphasizes the observer's 'seeing' an incoming elementary particle in the one dimension (1D) defined by each event-observer pair.

Events are geometric elements of physical reality; elementary particles are the event's 'fragments.' No elementary particle reveals its intact identity alone, in that its existence means already in interaction with, and as part of, the upcoming observer. Any event takes observation for an operational definition. As a model, reality is an evolving network among (observation) events, each of which terminates one set of elementary particles and then emits another set, entangled by the emitting event. An observation *event* (an observer) is under subsequent observations. The 'first' of the subsequent observation events a) collapses the wavefunction of the entangled particles and b) determines the observed particle [and the yet-to-be-observed other(s)]. In this sense, an elementary particle propagates from event to observer. A composite event or composite particle thus corresponds to a contiguous subsection of the event network.

As **Postulate 1**, *any event observation is along the '1D'—defined by the event-observer pair—that accommodates the quantized sub- or full-projection of the elementary particle's total angular momentum* ***J*** *relative to the observer.* For instance, an incident photon projects its orbital angular momentum as well as intrinsic spin (one $\hbar$), with the latter projected as (into) the 1D's *helicity* [13,14]. Observation must otherwise be radial. With no event in between the two defining events, the 1D connection differs from its counterpart in classical geometry. We will focus on the 1D, with the new connotation.

III. Mass and Observability

Per the Heisenberg uncertainty principle, events in spacetime are not volumeless mathematical points, that is, not as required of the (fictitious) measurements that would, from a 'point source' to a 'point detector,' always reproduce the speed-of-light constant. Sub- and superluminality must occur because of "noise." Demanding constancy in the speed of light, 'classical' SR offers *no* room for incidental (i.e., *prestatistical*, raw) data.

A physical constant is an a priori mathematical constant, but with uncertainty in (statistical) observation. Per incidental (prestatistical) measurement, the speed of light is a *random variable* c_R —imaginably needed for us, on further c_R measurements, to renormalize the scale of speed by *resetting* the new $\langle c_R \rangle$ to one [and then update $\Delta(c_R)$, etc.], where $\langle \_ \rangle$ is the statistical expectation {and $\Delta(\_)$ the standard deviation [15]}. It is our theoretical assertion that $\langle c_R \rangle$ $(\equiv c)$ $=1$. In the similar sense, $\hbar$ is constant.

For logging incidental data, SR becomes *stochastic* (see Appendix A, for derivation):

$$\left(\sqrt{c_R}\ t\right)^2 - \left(\frac{r}{\sqrt{c_R}}\right)^2 = \left(\sqrt{c_R}\ \tau\right)^2 \text{ (or } \tilde{t}^2 - \tilde{r}^2 = \tilde{\tau}^2 \text{, by definition),} \tag{1}$$

$$\left(\frac{E}{\sqrt{c_R}}\right)^2 - \left(\sqrt{c_R}\ p_r\right)^2 = \left(\frac{m_0}{\sqrt{c_R}}\right)^2 \text{ (or } \tilde{E}^2 - \tilde{p}_r{}^2 = \tilde{m}_0{}^2 \text{, by definition),} \tag{2}$$

where t is time increment, and E energy—per **Postulate 2**: *Speed-of-light c_R is a random variable serving as the yardstick (namely, $\tilde{r}/\tilde{t} = \tilde{E}/\tilde{p}_r = 1$,* or *$r/t = E/p_r = c_R$, 'as' $\tau = m_0 = 0$) specific to the incidental (prestatistical) event observation*—which the tilded (i.e., stochastic) dynamic variables describe. Equations (1) and (2) agree with two additional premises: a) convergence of stochastic SR to 'classical' SR, in the non-QM limit, and b) $\tilde{t}$-$\tilde{E}$, $\tilde{r}$-$\tilde{p}_r$, and $\tilde{\tau}$-$\tilde{m}_0$ conjugation (see Appendix B). Equations (1) and (2) represent beyond a unit change of variables, which requires a conversion constant (e.g., c), not a random variable.

Unlike 'classical' SR, stochastic SR offers every *event* (as well as mass particle) life and essence, namely, the *proper-time increment $\langle \tau \rangle$ and rest-mass $\langle m_0 \rangle$, both dictating (and being quasi dictated by) relations among fundamental uncertainties in the event observation* (see Appendix C):

$$\frac{1}{4}\langle \tau \rangle^2 \left[\Delta(c_{1,R})\right]^2 = \left[\Delta(r)\right]^2 - \left[\Delta(t)\right]^2, \tag{3}$$

$$\frac{1}{4}\langle m_0 \rangle^2 \left[\Delta(c_{1,R})\right]^2 = \left[\Delta(p_r)\right]^2 - \left[\Delta(E)\right]^2, \tag{4}$$

where $\Delta(c_{1,R}) \equiv \Delta(c_R)/\langle c_R \rangle$. [Per Eqs. (3) and (4), owing to zero $\Delta(c_{1,R})$, 'classical' SR a) leaves $\langle \tau \rangle$ and $\langle m_0 \rangle$ indeterminate and b) predicts $\Delta(r) = \Delta(t)$ and $\Delta(p_r) = \Delta(E)$ (see Fig. 2, for geometric representation) for *all* entities, erroneously including (mass-carrying) events and mass particles.] In addition, gravity physics mandates the speed of light deviate from constancy in observation if and only if gravity appears [11–13], that is, in observing any quantum event,

$$\Delta(c_R) > 0 \iff \text{"}\langle m_0 \rangle > 0 \ \left(\text{and } \langle \tau \rangle > 0\right)\text{."} \tag{5}$$

Equations (3)–(5), along with the measurement principle of $\Delta(\_) > 0$, indicate $\Delta(r)\Delta(p_r) > \Delta(t)\Delta(E)$, as expected of the space-time *asymmetry*. (See Fig. 2.)

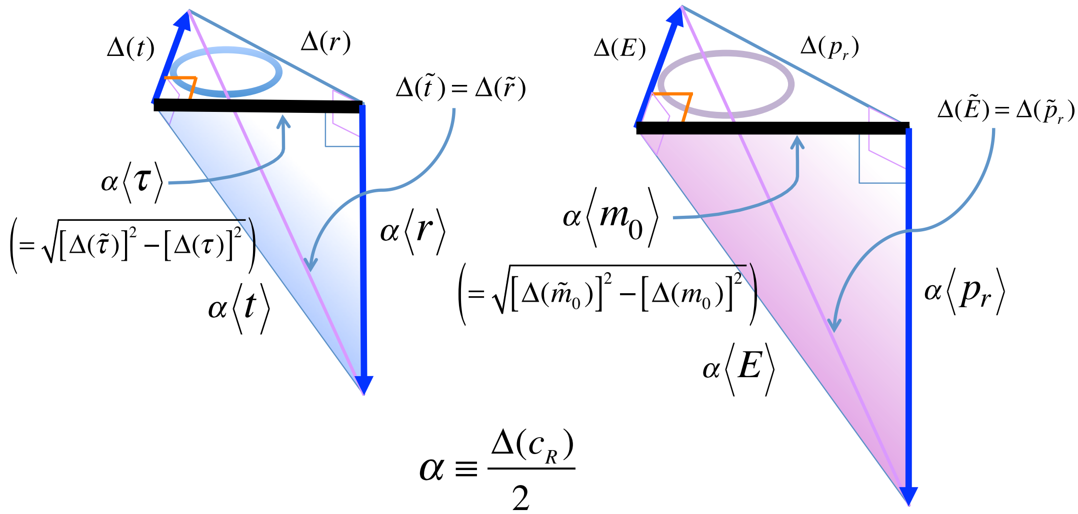


Fig. 2. Uncertainty in light-speed is vital to special relativity (SR).
In the conjugate tetrahedrons (with all facets being right-triangular), the nonzero α scales, into life, a) SR's two fundamental equations (shaded facets) and b) *all* fundamental uncertainties.

Equations (1) and (2) lead to the law of ROC in stochastic SR (see Appendix D):

$$\left(1+\langle\beta_R\rangle^2\right)\left(1+\tilde{\phi}\right)=2\,, \tag{6}$$

$$\langle\beta_R\rangle\equiv\frac{\langle\tilde{r}\rangle}{\langle\tilde{t}\rangle}\left(=\frac{\langle r\rangle}{\langle t\rangle}\right)=\frac{\langle\tilde{p}_r\rangle}{\langle\tilde{E}\rangle}\left(=\frac{\langle p_r\rangle}{\langle E\rangle}\right), \tag{7}$$

$$\tilde{\phi}\equiv\frac{\tilde{\sigma}_{OB}\ \left[\equiv\ \Delta(\tilde{r})\Delta(\tilde{p}_r)\right]}{\tilde{\sigma}_{PP}\ \left[\equiv\ \Delta(\tilde{\tau})\Delta(\tilde{m}_0)\right]}\,, \tag{8}$$

where $\tilde{\phi}$ is the event observability, with each constituent

$$\Delta(\tilde{X})=\sqrt{\left[\Delta(X)\right]^2+\frac{1}{4}\langle X\rangle^2\left[\Delta(c_{1,R})\right]^2}\,, \tag{9}$$

in Eq. (8). As another random variable, β_R is the *event*'s incidental velocity, relative to the immediate follow-on *mass* entity, which is either the elementary particle or the observer (to whom the event emits a massless elementary particle). Via Eq. (9), $\tilde{\sigma}_{PP}$ [defined in Eq. (8)] becomes proper of—because $\Delta(c_{1,R})$ is characteristic of—the event *observation*; in comparison, σ_{PP} $\left[\equiv\Delta(\tau)\Delta(m_0)\right]$ is proper only of the *event*, which would be virtual if unobserved, that is, if $\Delta(c_{1,R})$ undefined.

Equation (6), with $\Delta(\_)>0$, enforces $\langle\beta_R\rangle\neq 0$ (see Appendix E), namely, $0<\left|\langle\beta_R\rangle\right|$ (<1) —and $0<\tilde{\phi}<1$. Self observation is therefore infeasible, rendering a) $\langle X\rangle\Delta(c_{1,R})\neq 0$ in Eq. (9) and b) $\tilde{\sigma}_{OB}>\sigma_{OB}$ $\left[\equiv\Delta(r)\Delta(p_r)\right]$ and $\tilde{\sigma}_{PP}>\sigma_{PP}$. Besides, $\Delta(c_{1,R})$ couples the entire set of $\Delta(\tilde{X})$, only when none of the corresponding $\langle X\rangle$ is zero, which is always true in stochastic SR. Stationarity, with '$\langle r\rangle=\langle p_r\rangle=\left|\langle\beta_R\rangle\right|=0$,' refers to an approachable but unreachable limit.

IV. Spin and Event-size

This section verifies Eq. (6), in the fiducial (triple-premise) limit where a) $\Delta(c_{1,R})$ vanishes [in Eq. (9)], b) the observed elementary particle has quasi 'completed' its interactional redshift 'in' the event, and c) the event is speedless to the observer. Per Postulates 1 and 2, the observed event-size $\tilde{\sigma}_{OB}$ in the limit reduces to σ_{OB} that equals the 1D projection-magnitude of the particle's $\boldsymbol{J}$ [13,14], where $\boldsymbol{J}$ is the vectorial sum of the intrinsic spin $\boldsymbol{S}$ and orbital angular momentum $\boldsymbol{L}$. Observability $\tilde{\phi}$ becomes a rational number, per the quantization of angular momentum.

In the limit, an *elementary* particle free of $\boldsymbol{S}$ and $\boldsymbol{L}$ would violate the Heisenberg uncertainty principle (i.e., $\sigma_{OB} \geq \hbar/2$), for squeezing $\tilde{\sigma}_{OB}$ $(>\sigma_{OB})$ and hence σ_{OB} to zero (that is, to below $\hbar/2$). Owing to never forbidding the projection of $\boldsymbol{L}$ from being zero, *Nature prohibits spin-zero elementary (structureless) particles*—agreeing with E. Wigner's seminal analysis on the Lorentz group [16,17] of SR. [So the "discovered (spin-zero) Higgs boson" cannot be 'elementary' (see Appendix F).] By the same token, a massless elementary particle's $\boldsymbol{S}$ must project onto the 1D, creating the particle's *nonzero* helicity [16,17] to warrant its (nonzero) observability in case the projection of $\boldsymbol{L}$ is zero.

Per the Pauli vector in isotropic 3D space, formal derivation shows (in Appendix G)

$$\left[\hat{\tau},\, \hat{m}_0\right] = -2i\hbar\hat{I}\,, \tag{10}$$

with ^ labeling quantum operators and $\hat{I}$ being the identity operator—and the doubling in commutator 'size' is a mathematical mandate, so far missing in the literature. Equation (10) results in [through Ineq. (G10)] the *proper* uncertainty principle:

$$\sigma_{PP} \geq \hbar\,, \tag{11}$$

with which the Heisenberg uncertainty principle $(\sigma_{OB} \geq \hbar/2)$ concurs, because a) $\sigma_{PP} > \sigma_{OB}$ and b) the smallest nonzero angular momentum is $\hbar/2$.

Consider, in the limit, the *mildest* electron-positron (e^--e^+) pair-production event (speedless to the lab). Per Eq. (6), the default event-fraction $\tilde{\phi}$ of $1/2$ 'observed' by either e^- or e^+—or by a 'lab-stationary' observer who detects either e^- or e^+—indeed leads to the proper e^--e^+ energy gap of twice the rest-mass m_e of e^- (as verified in Appendix H). *Consistently*, the default '$\tilde{\phi} = 1/2$' is also the ratio of $\hbar/2$ over $\hbar$, where a) numerator $\hbar/2$ is the electron-spin magnitude (per Postulate 1) or, equivalently, the mildest σ_{OB} for a speedless event [per the (nonrelativistic) Heisenberg uncertainty principle] and b) denominator $\hbar$ is the mildest σ_{PP} (per the proper uncertainty principle).

In the triple limit, collision between two (spin-1) photons, without relative $\boldsymbol{L}$, may cause $\sigma_{PP} = 0$ (unobservable; forbidden), $\hbar$ (just discussed), or $2\hbar$. We address the last as another example. With the conservation of linear momentum, Eq. (6) predicts the two resulting particles (originally entangled) to have $\tilde{\phi} = 1/4$ and $3/4$—the former comes with $\sigma_{OB} = \hbar/2$, $\left|\langle \beta_R \rangle\right| = \sqrt{3/5}$, and $\langle m_0 \rangle = m_e$; the latter with $\sigma_{OB} = 3\hbar/2$, $\left|\langle \beta_R \rangle\right| = \sqrt{1/7}$, and quasi 'rest-mass $\langle m_0 \rangle$' $= 3m_e$ (with the increase due to $\boldsymbol{L}$'s projection magnitude $\hbar$) (see Table 1). Still, the two $\tilde{\phi}$'s add up to one, as anticipated of a single event that is speedless to two 'complementary' observers. [When $\sigma_{PP} = 2\hbar$, the requirement that $|\boldsymbol{L}|$ be an integer multiple of $\hbar$ rules out $\tilde{\phi} = 1/2$ for both particles (see Table 1).]

Table 1. Relation between 'rational $\tilde{\phi}$' and $\left|\langle \beta_R \rangle\right|$.

Proper event-size $\tilde{\sigma}_{PP}$ ($\hbar$)	Observable event-size $\tilde{\sigma}_{OB}$ ($\hbar$)	Event observability $\tilde{\phi}$	*Equivalent* speed [a] $\left|\langle\beta_R\rangle\right|$	'Complete' interactional redshift [b] z
1	1/2	1/2	$\sqrt{1/3}$	~ 0.932
3/2	1/2	1/3	$\sqrt{2/4}$	~ 1.414
	1	2/3	$\sqrt{1/5}$	~ 0.618
2	1/2	1/4	$\sqrt{3/5}$	~ 1.806
	1	2/4	$\sqrt{2/6}$	~ 0.932
	3/2	3/4	$\sqrt{1/7}$	~ 0.488
etc.				

[a] See Eq. (6).
[b] See Eq. (12).

As the event is in (radial) motion [i.e., relaxing Premise 'c)'] in the triple-premise limit, Eq. (6) permits 'tuning' of $\tilde{\phi}$ from such exemplified rational numbers dictated by $\boldsymbol{S}$ and $\boldsymbol{L}$. For instance, in the event of the mildest e^{-}-e^{+} annihilation, the observability $\tilde{\phi}$ via either one of the two resulting photons becomes smaller than $\hbar/(2\hbar)$, whereas the photon, while yet to be observed, retains its helicity $\hbar$ and zero 1D-projection of $\boldsymbol{L}$.

See Section V, for the general meaning of fractional $\tilde{\phi}$ (rational or irrational); Section VIII, for the significance of compromised $\tilde{\phi}$ in QM.

V. Fractional Observability

For observation via (for now) a *massless* elementary particle, the law of ROC (so far in stochastic SR) turns into

$$\tilde{\phi}(z) = \frac{2}{(1+z)^2 + (1+z)^{-2}} \text{ (see Fig. 1),} \tag{12}$$

per Eq. (6) and (as a bait) the Doppler relation [10,11] of $\langle\beta_R\rangle$ and z—where $\langle\beta_R\rangle$ is meaningful only between mass entities, and z is of the massless elementary particle travelling in between. Now that the particle-wave duality is universal, Eq. (12) holds for observation via any event-to-observer particle, *whether massless or not*.

Derivation of Eq. (6) and hence (12) does not differentiate the meaning for $\Delta(X)$ between a) of a fundamental quantum event and b) of a composite 'event' spanning, at our choice, a contiguous subsection of the event network. Equation (12) applies to observation of composite cosmic events or objects, in the (quasi) 'universe of stochastic SR' for now [and the universe of GR (see Section VI)].

The observability $\tilde{\phi}$ of a fundamental *event* is that of the event-to-observer elementary *particle*, as referenced to the *particle*'s nominal initial state whose wavelength λ_0 is proper to (and 'at') the thereby referenced *event*. Equation (12) permits different definitional choices for the (referenced) *event* from the same physical 'happening' (e.g., an e^--e^+ annihilation). For a *given* observed λ, a different choice for λ_0—namely, a different definitional choice for the (referenced) event—leads to a different pair of z and (fractional) $\tilde{\phi}$, and vice versa. That is, for a given λ, a different z a) corresponds to a different choice for the event and b) results in a different $\tilde{\phi}$ per Eq. (12). [Such disciplined flexibility to define the event also holds in GR (see Section VI).]

For instance, to a *unidirectional* observer, the e^--e^+ annihilation event corresponds to detecting *one* of the two resulting photons, and the photon may have partially fulfilled its annihilational redshift, to an arbitrary but specific extent. The 'partial' event may *further* 'redshift' by z' relative to the observer and 'reveal' the z'-dependent observability $\tilde{\phi}'$ (of the 'partial' event), per Eq. (12). So we, as observers 'unidirectional' to *any* cosmic event (or object), always get to define the counterpart 'stationary event (object) for study' as if it had $z = 0$ and $\tilde{\phi} = 1$ [in the universe of GR (see below)]. This is a leap in conception; recall, under the "triple limit" of Section IV, it takes two accessible $\tilde{\phi}$'s to sum up to one.

VI. True Observable

In portraying physical laws, the principle of relativity [10–12] demands 'equivalence' among all observers. From *our* perspective of 'event vs. (generalized) observer,' the principle translates to: *Any (global) physical law is in terms of a set of <u>observer's local observables</u> that all observers nominally share—and thereby share the law—so <u>we</u> can correlate observers for a common event* $\underline{E}$ (underscored for distinction from energy E), *via its intrinsic property*.

As a single event, the observer (locally) 'owns' its observables v_i (with *i* being an index). Manifesting the incoming elementary particle to the observer, such local v_i are 'functions' $v_i(\underline{E}, R_{\underline{E}O})$ of a) event $\underline{E}$ that emitted the elementary particle and b) the relativity context (denoted as a quasi variable $R_{\underline{E}O}$, for shorthand) connecting $\underline{E}$ to the observer. (In this way, we skip the debate on the existence of the graviton.)

To be eligible as a (global) law, the local relation among the v_i involves no $R_{\underline{E}O}$ as otherwise it would contradict the default observer-specific localness and disqualify the "law." Namely, each law results from covariance among a set of v_i, regardless of $R_{\underline{E}O}$, and corresponds to an equation explicit of v_i, but 'implicit' of $R_{\underline{E}O}$ through $v_i(\underline{E}, R_{\underline{E}O})$.

In notation, the above conception condenses to

$$f_{LAW}(v_1, v_2, v_3, ...) = 0, \qquad (13)$$

where f_{LAW} is the expression describing the law—prohibiting $f_{LAW}(v_1, v_2, ..., R_{\underline{E}O}) = 0$. To the generalized observer, Eq. (13) conceals v_i's dependence on $R_{\underline{E}O}$. To us,

$$f_{LAW}\left[v_1(\underline{E}, R_{\underline{E}O}),\ v_2(\underline{E}, R_{\underline{E}O}),\ v_3(\underline{E}, R_{\underline{E}O}),\ \ldots\right] = 0\,, \tag{14}$$

in that conscious observers can conceive of the event network, and then of $\underline{E}$ and $R_{\underline{E}O}$.

Because of not explicitly involving $R_{\underline{E}O}$ *, Eq. (13) is valid even when* $R_{\underline{E}O}$ *is in the asymptotic limit of stochastic SR*, which can therefore serve as a scaffold for helping derive physical laws among *true* v_i . Both $\tilde{\phi}$ $\left(\equiv \tilde{\sigma}_{OB}/\tilde{\sigma}_{PP}\right)$ and z $\left[\equiv \left(L_{OB}/L_{PP}\right) - 1\right]$ act as $v_i(\underline{E}, R_{\underline{E}O})$, for each involves merely a simple ratio with a) the numerator reflecting only $\underline{E}$ and $R_{\underline{E}O}$ and b) the denominator only $\underline{E}$. Seemingly trivial, **Postulate 3** states $\tilde{\phi}$ *and* z *are physical observables that comply with the principle of relativity*—warranting $\tilde{\phi}$ and z may covary into a law (invariant to any permissible $R_{\underline{E}O}$). Thereby, Eq. (12) holds in GR, even *after we obliterate all the scaffolding context of stochastic SR*—such as $\tilde{\phi}$'s 'anatomy' in terms of $\Delta(\_)$ [for the observer 'may' be clueless of $\tilde{r}$, $\tilde{p}_r$, $\tilde{\tau}$, and $\tilde{m}_0$, let alone their $\Delta(\_)$'s], Eq. (6) [for $\langle \beta_R \rangle$ is a pseudo observable (see Appendix I)], etc.

In GR-based cosmological models, Eq. (12) ensures a) the observability of the cosmos mathematically *integrable* over the entire domain of redshift and b) 0^+ observability expected of the Big Bang's extreme onset (see Appendix J)—though Eq. (12) is 'neutral' to any cosmological model, whether involving the Big Bang.

VII. No 'Cosmic Acceleration'

Between quantum uncertainties and GR, an interfacing cornerstone is stochastic SR, (not 'classical' SR). Stochastic SR embeds Eq. (12), and therefore so does (should) quantum gravity, along with GR [as a limit of zero local $\Delta(c_{1,R})$] (see Appendix K). Without our prior awareness, Eq. (12) is intrinsic to the *complete* GR-based cosmological model—which our observation and observational interpretation help 'complete.' It remains a must to rectify, with the ROC effect [i.e., Eq. (12)], the observational interpretation of the otherwise incomplete GR-based model.

Being the major "evidence of cosmic acceleration [1–3]," Fig. 3 illustrates 'observed-magnitude [5] $\underline{m}$ (underscored for distinction from mass m) vs. redshift z' of Type Ia supernovae. In the figure, the current article depicts the ROC-corrected observed magnitude (curve of blue dots) for the critical cosmic expansion (CCE): (see Appendix L for derivation)

$$\underline{m}_{CCE}(ROC;\, z) \,\equiv\, \underline{m}_{CCE}(No\ ROC;\, z) \,-\, 2.5\log_{10}\left(\tilde{\phi}(z)\right), \tag{15}$$

where $\underline{m}_{CCE}(No\ ROC;\, z)$ is the CCE curve as if no ROC associated with the universe traversing photons that our observation terminates. Curve $\underline{m}_{CCE}(ROC;\, z)$ intersects 21 uncertainty bars—of the 28 data points—only one fewer than Ref. [1]'s *modeled best fit* (thin blue curve, which gives parameter $\Omega_\Lambda \approx 2/3$). In particular, $\underline{m}_{CCE}(ROC;\, z)$ intersects eight uncertainty bars of all nine data points (red dots) from the High-Z

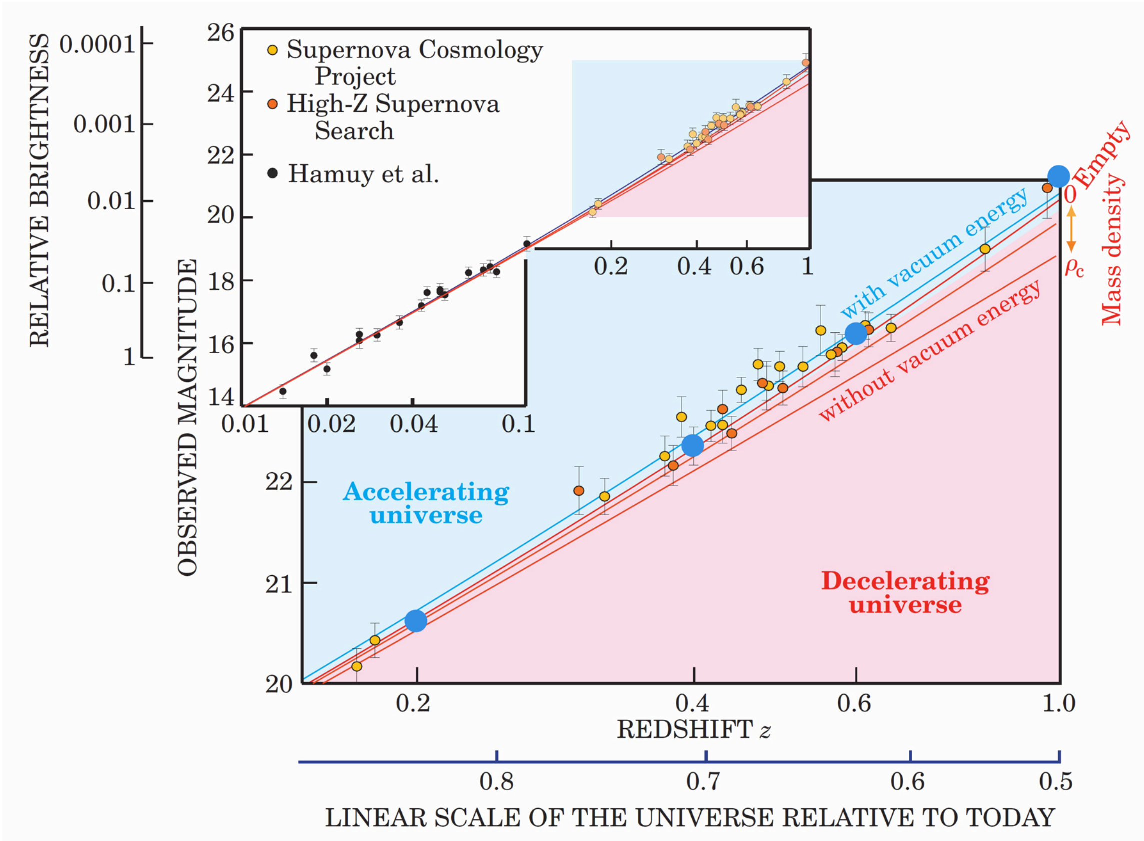


Fig. 3. Observed-magnitude [5] $\underline{m}$ vs. redshift z of Type Ia supernovae, denying "cosmic acceleration." (Part of the figure and legend is reproduced with permission from Ref. [1], Copyright 2003, American Institute of Physics.)

The original legend reads

> "*Observed magnitude versus redshift is plotted for well-measured distant and (in the inset) nearby Type Ia supernovae. For clarity, measurements at the same redshift are combined. At redshifts beyond z = 0.1, the cosmological predictions (indicated by the curves) begin to diverge, depending on the assumed cosmic densities of mass and vacuum energy. The red curves represent models with zero vacuum energy and mass densities ranging from the critical density ρ_c down to zero (an empty cosmos). The best fit (blue line) assumes a mass density of about $\rho_c/3$ plus a vacuum energy density twice that large—implying an accelerating cosmic expansion.*"

Equation (15) creates the theoretical observed-magnitude $\underline{m}_{CCE}(ROC; z)$ (curve of blue dots) for the *critical* cosmic expansion (CCE), after correction for the ROC (for 'relativistic observability compromise') effect. Free of parameter fitting, the effect lifts the "orthodox" CCE curve (labeled with ρ_c) to $\underline{m}_{CCE}(ROC; z)$, which coincides with the observational data, to within uncertainty.

Supernova Search [2]. Denying "cosmic acceleration," the supernovae data coincide with the corrected CCE curve, to within observational uncertainty.

The correction is based all on common knowledge (i.e., Postulates 0–3) and free of parameter fitting. By Occam's razor, "cosmic acceleration" appears artifactual.

The law of ROC also appears to dissolve the crisis, identified by Ref. [18], of missing 400% of hydrogen-atom ionizing photons in cosmological observation at z slightly above 2—where Fig. 1 matches the "400%" with $(1-\tilde{\phi})/\tilde{\phi}$.

A further check on the law of ROC is to account for the enigma raised by Ref. [19]: Why has it been easier to see gas *relativistically* blowing toward than away from us, at all high-z quasars? A strong candidate answer lies in the monotonicity of $\tilde{\phi}(z)$ in Fig. 1.

VIII. Concluding Remarks

A. Relativistic uncertainty

As $1+z$ is $\Gamma \left(\equiv L_{OB}/L_{PP}\right)$, Eq. (12) entails the fundamental quantum event's observability *amplitude* (i.e., observation *probability amplitude*)

$$\psi = e^{i\delta}\sqrt{\frac{2}{\Gamma^2+\Gamma^{-2}}}\,, \tag{16}$$

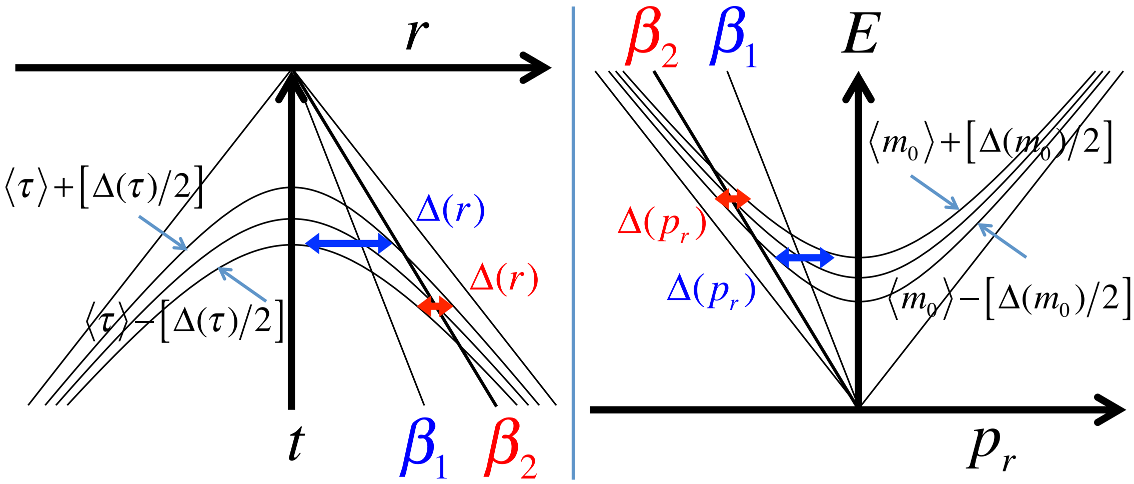
where $e^{i\delta}$ is a unitary phase factor—in the event-observer direction, via the 1D-defining elementary particle, whether massless or not. (Namely, $\tilde{\phi}=\psi^*\psi$.) Amplitude ψ profiles a resonance in Γ (or Γ^{-1}), peaking at $\Gamma=1$, so does $\tilde{\phi}$.

Before received and collapsed, the particle, regardless of Γ, retains the same 1D projection magnitude of the particle's total angular momentum $\boldsymbol{J}$ as if the particle-emitting event were speedless (to the observer). [This 1D projection magnitude coincides with $\tilde{\sigma}_{OB}$ only in the "triple limit" (see Section IV).]

Equation (16) leads to the <u>*relativistic* uncertainty principle</u> [via Eq. (G8b) and Ineq. (G10), in Appendix G]:

$$\Delta(r)\Delta(p_r)\left(\equiv\sigma_{OB}\right) \ge \frac{\hbar}{\Gamma^2+\Gamma^{-2}}\,, \tag{17}$$

of which the Heisenberg uncertainty principle is the *nonrelativistic* extreme (with $\Gamma=1$). The new principle allows relativity, through Γ, to a) squeeze the lower-bound of σ_{OB} to below $\hbar/2$ and b) diminish the observer-effective vacuum energy. As a hint from 'classical' SR, Fig. 4 illustrates how relativistic <u>*event-size contraction*</u> results in the lower-bound squeezing—though straightforward, the visualization has slipped through the crack since W. Heisenberg in 1927. Inequalities (11) and (17) are principles of both uncertainty and event-size. It is event-size contraction that helps enact the law of ROC.



$$\underline{\Delta(r)\Delta(p_r)}_{\beta_1} > \underline{\Delta(r)\Delta(p_r)}_{\beta_2}$$
$$as\ \beta_1 < \beta_2$$

Fig. 4. The Heisenberg uncertainty principle needs refinement: Contraction of event-size $\Delta(r)\Delta(p_r)$ **—hint from 'classical' special relativity**.

A mass entity (either event or particle) possesses its intrinsic $\langle\tau\rangle$, $\Delta(\tau)$, $\langle m_0\rangle$, and $\Delta(m_0)$, all nonzero and Lorentz-invariant. Within the past light-cone in the t-r diagram (upper left), any observed mass entity locates at the intersection of a) the $\langle\tau\rangle$-contour (hyperbolic branch) and b) the β-contour (origin-passing straight line), where β is the entity's unitless speed. Characteristic of the entity, the (hyperbolic) contours of $\langle\tau\rangle+(\Delta(\tau)/2)$ and $\langle\tau\rangle-(\Delta(\tau)/2)$ 'pinch' the entity's $\Delta(t)$ and $\Delta(r)$. Under the pinch, as β varying from 0 to 1^- (that is, the β-line tilting toward either side of the light-cone), the entity progresses with *ever-decreasing* $\Delta(t)$ and $\Delta(r)$, both asymptotically to 0^+. • In the E-p_r diagram (upper right), the entity likewise progresses with *ever-decreasing* $\Delta(E)$ and $\Delta(p_r)$. • Per both diagrams, $\Delta(r)\Delta(p_r)$ diminishes, as β increases from 0, namely, as Γ [in Ineq. (17)] deviates (increases or decreases) from 1. So the greatest lower-bound of $\Delta(r)\Delta(p_r)$ peaks with Heisenberg's $\hbar/2$, only at $\Gamma=1$.

In any physical measure, the generalized observer must be nonzero finite; it lacks precision for 0 and capacity for ∞. The more λ approaches 0 or ∞, the less discernible the (wave-emitting) event. Accepting "cosmic acceleration,"—namely, denying relativistic event-size contraction or the law of ROC—(oxymoronically) connotes 100% statistical observability of an event emitting a wave with λ '$=$' 0 or ∞, that is, a "wave of *no* wave!" It is unsurprising that the law of ROC dissolves all three cosmic enigmas mentioned in Section VII, free of parameterization.

Holding for the cosmological observation and the e^{-}-e^{+} interaction, Eq. (16) [with Ineq. (17), i.e., the relativistic uncertainty principle] partly hints on how to address integrability issues of quantum field theory. For instance, the 'spin network' appears incomplete, in contrast to the event network per Eq. (16).

B. Lab testability

A recommended check on Fig. 1 follows. We a) generate an electron beam—tunable in speed up to 0.9 (1.2 Mev) or higher—to annihilate positrons steady in number density and 'stationary' (e.g., in an electromagnetic trap) to the lab, and b) observe, at a grazing angle to the collision axis, how the resulting photon intensity varies with the annihilation *event's* speed (i.e., half the incident electron's speed). The intensity measurements at the grazing angle are in opposing directions, one for blueshift, and the other redshift. This experiment checks Fig. 1 with the event speed below 0.5 to the lab.

Even better will be to employ an e^{-}-e^{+} collider a) tunable in each beam-speed up to 0.9 or higher but also b) reversible in direction for one of the two (nearly coaxial) beams, to further create the catch-up collisions that help check Fig. 1 with the event speed *above* 0.5 to the lab. Such experiments may settle the debate.

Appendix A: Stochastic Special Relativity

This appendix helps Section III justify replacing 'classical' special relativity (SR):

$$t^2 - r^2 = \tau^2, \tag{A1}$$

$$E^2 - p_r^{\ 2} = m_0^{\ 2}, \tag{A2}$$

with stochastic SR:

$$\left(\sqrt{c_R}\ t\right)^2 - \left(\frac{r}{\sqrt{c_R}}\right)^2 = \left(\sqrt{c_R}\ \tau\right)^2, \tag{A3}$$

(or $\tilde{t}^2 - \tilde{r}^2 = \tilde{\tau}^2$, by variable definition)

$$\left(\frac{E}{\sqrt{c_R}}\right)^2 - \left(\sqrt{c_R}\ p_r\right)^2 = \left(\frac{m_0}{\sqrt{c_R}}\right)^2, \tag{A4}$$

(or $\tilde{E}^2 - \tilde{p}_r^{\,2} = \tilde{m}_0^{\,2}$, by variable definition).

Here begins the derivation. Postulate 2, with the two premises listed below Eq. (2), demands 'softening' Eqs. (A1) and (A2) as

$$\left(c_R^{\;a}\; t\right)^2 - \left(\frac{r}{c_R^{\;1-a}}\right)^2 = \left(c_R^{\;a}\;\tau\right)^2, \tag{A5}$$

(or $\tilde{t}^2 - \tilde{r}^2 = \tilde{\tau}^2$, as shown below)

$$\left(\frac{E}{c_R^{\;a}}\right)^2 - \left(c_R^{\;1-a}\; p_r\right)^2 = \left(\frac{m_0}{c_R^{\;a}}\right)^2, \tag{A6}$$

(or $\tilde{E}^2 - \tilde{p}_r^{\,2} = \tilde{m}_0^{\,2}$, as shown below)

leaving statistical theory alone to determine the value of parameter a.

By the definition of $\Delta(\_)$, we have

$$\Delta(\tilde{\tau}^2) = 2\left|\langle\tilde{\tau}\rangle\right|\Delta(\tilde{\tau}). \tag{A7}$$

Owing to the statistical covariance between $\tilde{t}-\tilde{r}$ and $\tilde{t}+\tilde{r}$ being zero, Eq. (A5) leads to

$$\Delta(\tilde{\tau}^2) = \sqrt{\left(\langle\tilde{t}\rangle+\langle\tilde{r}\rangle\right)^2\left[\Delta\left(\tilde{t}-\tilde{r}\right)\right]^2 + \left(\langle\tilde{t}\rangle-\langle\tilde{r}\rangle\right)^2\left[\Delta\left(\tilde{t}+\tilde{r}\right)\right]^2}, \tag{A8}$$

which, along with Eq. (A7), becomes

$$\Delta(\tilde{\tau}) = \sqrt{\frac{\left[\Delta(\tilde{t})\right]^2+\left[\Delta(\tilde{r})\right]^2}{2}}\sqrt{\frac{1+\langle\beta_R\rangle^2}{1-\langle\beta_R\rangle^2}}, \tag{A9}$$

with $\langle\beta_R\rangle^2$ substituting for $\left|\langle\tilde{r}\rangle/\langle\tilde{t}\rangle\right|^2$ $\left(=\left|\langle r\rangle/\langle t\rangle\right|^2\langle c_R\rangle^{-2}\right)$. (Recall r and t are each a differential increment in spacetime, by definition.) In Eq. (A9), $\langle\beta_R\rangle$ must be an *expectation* value—of the event's incidental velocity β_R (to the observer) as normalized relative to $\langle c_R\rangle$—in that all three other entities [i.e., $\Delta(\tilde{\tau})$, $\Delta(\tilde{t})$, and $\Delta(\tilde{r})$] are statistical values (of the event observation). $\langle\beta_R\rangle$ must also correspond to the *radial* velocity of the event as the event-observer pair defines only the radial 1D. (Similar to that of c_R, subscript R reminds β_R is a stochastic random variable.)

'Restarting' from $\tilde{\tau} = -(\tilde{t}^2 - \tilde{r}^2)^{1/2}$ [seemingly redundant to Eq. (A5)] gives

$$\Delta(\tilde{\tau})=\sqrt{\left[\Delta(\tilde{t})\right]^2+\langle\beta_R\rangle^2\left[\Delta(\tilde{r})\right]^2}\sqrt{\frac{1}{1-\langle\beta_R\rangle^2}}\,. \tag{A10}$$

Equating the right-hand sides of Eqs. (A9) and (A10) indicates

$$\Delta(\tilde{t})=\Delta(\tilde{r})\,, \tag{A11}$$

regardless of $\langle\beta_R\rangle$ and $\Delta(\tilde{\tau})$. The mathematical analogy between Eqs. (A5) and (A6) legitimates substituting $\langle\beta_R\rangle^2$ for $\left|\langle\tilde{p}_r\rangle/\langle\tilde{E}\rangle\right|^2$ $\left(=\left|\langle p_r\rangle/\langle E\rangle\right|^2\langle c_R\rangle^2\right)$ as well and entails

$$\Delta(\tilde{E})=\Delta(\tilde{p}_r)\,, \tag{A12}$$

regardless of $\langle\beta_R\rangle$ and $\Delta(\tilde{m}_0)$.

By definition, Eq. (A11) is

$$\Delta\left(c_R{}^a t\right)=\Delta\left(\frac{r}{c_R^{1-a}}\right), \tag{A13}$$

which expands into

$$\left[\Delta(t)\right]^2+\left[a^2\langle\tau\rangle^2+(2a-1)^2\langle r\rangle^2\right]\left[\Delta(c_{1,R})\right]^2=\left[\Delta(r)\right]^2\,, \tag{A14}$$

with $\Delta(c_{1,R})$ being the unitless ratio of $\Delta(c_R)/\langle c_R\rangle$. Per Eq. (A14) and the measurement principle of $\Delta(\_)>0$, parameter a—in Eqs. (A5) and (A6)—must be $1/2$ in that $\Delta(r)$ is independent of $\langle r\rangle$ in statistics. So we get Eqs. (A3) and (A4).

Appendix B: Conjugation of Time and Energy

As defined in Ref. [20], the time operator can be self-adjoint and compatible with the energy operator having a spectrum bounded from below. "On their common domain, the operators of time and energy satisfy the expected canonical commutation relation. Pauli's theorem [21] is bypassed because the correspondence between time and energy is not given by the standard Fourier transformation, but by a variant thereof known as the holomorphic Fourier transformation. [20]"

Appendix C: 'Definitions' of $\langle\tau\rangle$ and $\langle m_0\rangle$

With $a=1/2$, Eq. (A14) reduces to an *operational* quasi definition of $\langle\tau\rangle$:

$$\frac{1}{4}\langle\tau\rangle^2\left[\Delta(c_{1,R})\right]^2=\left[\Delta(r)\right]^2-\left[\Delta(t)\right]^2. \tag{C1}$$

One can verify the interplay consistency among the three Δ's in Eq. (C1) on a *classical*-SR spacetime diagram, which reflects $\Delta(c_{1,R})$ by 'backward' referencing the precise light cone to the fuzzy event 'confined' with $\Delta(t)$, $\Delta(r)$, and invariant $\Delta(\tau)$. Via analogy between Eqs. (A3) and (A4), Eq. (C1) implies an *operational* quasi definition of $\langle m_0\rangle$:

$$\frac{1}{4}\langle m_0\rangle^2\left[\Delta(c_{1,R})\right]^2=\left[\Delta(p_r)\right]^2-\left[\Delta(E)\right]^2. \tag{C2}$$

$\langle\tau\rangle$ and $\langle m_0\rangle$ must be a) positive for any physical *event* and b) nonnegative for any elementary *particle*. $\langle\tau\rangle$ and $\langle m_0\rangle$ dictate the relations among the fundamental Δ's in the event observation—and among those of an observed particle. Still, an elementary particle may be proper-timeless and rest-massless.

Division by zero is indeterminate. It is (nonzero) $\Delta(c_{1,R})$ in Eqs. (C1) and (C2) that turns on the event's and the elementary particle's proper-time and rest-mass as dynamic variables. No $\Delta(c_{1,R})$ is an intrinsic flaw with 'classical' SR. *By default, SR should refer to stochastic SR, not 'classical' SR.*

Appendix D: Observability in Stochastic SR

Equation (A11) converges Eqs. (A9) and (A10) to the same form(s):

$$\Delta(\tilde{\tau})=\begin{cases}\Delta(\tilde{t})\sqrt{\dfrac{1+\langle\beta_R\rangle^2}{1-\langle\beta_R\rangle^2}} \text{ or, equivalently,}\\ \Delta(\tilde{r})\sqrt{\dfrac{1+\langle\beta_R\rangle^2}{1-\langle\beta_R\rangle^2}}.\end{cases} \tag{D1}$$

Likewise, Eq. (A12) results in

$$\Delta(\tilde{m}_0)=\begin{cases}\Delta(\tilde{E})\sqrt{\dfrac{1+\langle\beta_R\rangle^2}{1-\langle\beta_R\rangle^2}} \text{ or, equivalently,}\\ \Delta(\tilde{p}_r)\sqrt{\dfrac{1+\langle\beta_R\rangle^2}{1-\langle\beta_R\rangle^2}}.\end{cases} \tag{D2}$$

Involving no QM, the derivations of Eqs. (D1) and (D2) depend only on a) the definition of standard deviation $\Delta(\_)$ and b) stochastic SR. At the quantum-event level, $\Delta(\_)$ must correspond to the observational uncertainty. Equations (D1) and (D2) are therefore essential in quantum observation, so is their multiplicative combination, which gives

$$\tilde{\phi} = \frac{1-\langle \beta_R \rangle^2}{1+\langle \beta_R \rangle^2}, \tag{D3}$$

or, equivalently,

$$\left(1+\langle \beta_R \rangle^2\right)\left(1+\tilde{\phi}\right) = 2\,, \tag{D4}$$

where

$$\tilde{\phi} \equiv \frac{\tilde{\sigma}_{OB}\ \left[\equiv\ \Delta(\tilde{r})\Delta(\tilde{p}_r)\right]}{\tilde{\sigma}_{PP}\ \left[\equiv\ \Delta(\tilde{\tau})\Delta(\tilde{m}_0)\right]} \tag{D5a}$$

$$= \frac{\Delta(\tilde{t})\Delta(\tilde{E})}{\tilde{\sigma}_{PP}}, \tag{D5b}$$

with each constituent

$$\Delta(\tilde{X}) = \sqrt{\left[\Delta(X)\right]^2 + \frac{1}{4}\langle X \rangle^2 \left[\Delta(c_{1,\,R})\right]^2}\,, \tag{D6}$$

in Eqs. (D5a) and (D5b). So $\langle X \rangle \Delta(c_{1,\,R})\ (\neq 0)$ increases the event-size.

In the limit of zero $\Delta(c_{1,\,R})$, $\tilde{\phi}$ becomes $\bar{\phi} \equiv \dfrac{\Delta(r)\Delta(p_r)}{\Delta(\tau)\Delta(m_0)}$ or, equivalently, $\dfrac{\Delta(t)\Delta(E)}{\Delta(\tau)\Delta(m_0)}$, where the two *nonzero* numerators highlight ‘classical’ (nonstochastic) SR’s self-contradiction between a) nonzero event *volumes* [i.e., $\Delta(t)\Delta(r)$’s; not event-sizes] in spacetime and b) the a priori constant speed of light that requires zero event volumes.

Appendix E: No Stationarity

Equation (D4) leads to

$$\left|\langle \beta_R \rangle\right| \Delta\left(\langle \beta_R \rangle\right) = \frac{\Delta(\tilde{\phi})}{\left(1+\langle \tilde{\phi} \rangle\right)^2}, \tag{E1}$$

which prohibits $\langle \beta_R \rangle$ from being zero in that $\Delta(\_)$ may never be zero. [No stationarity agrees with the (positive) zero-point energy in QM.] The nominal missing point of $\tilde{\phi}$ at $\langle \beta_R \rangle = 0$ leaves intact the prediction of $\lim_{|\beta_R| \to 0^+} \tilde{\phi} = 1$, per Eq. (6) or (D4).

Appendix F: 'Discovery' of Higgs Boson

By definition, an elementary particle is structureless. The discovery announcement {3 July 2012, at the LHC [9]} of the 'elementary' (spin-0) Higgs boson [22] fell short of verification on whether it was structureless. Should it have been structureless, E. Wigner's seminal analysis of the Lorentz group [16]—which forbids spin-zero elementary particles—would be incorrect [17], so would special relativity (SR), of which the Lorentz group is characteristic. It is improper to celebrate the "discovery" with SR.

Did we mistake a meson (i.e., a quark-antiquark pair) for the "Higgs boson," rhyming the history, in the 1940s, we mistook pions for the *elementary* mediators between protons? Popularity voting does not determine physics.

Appendix G: Derivation of $[\hat{\tau}, \hat{m}_0] = -2i\hbar\hat{I}$

Applying the (Hermitian) Pauli matrices [23,24] to two independent operators $\hat{A}$ and $\hat{B}$ of same dimension, one can synthesize two degree-2 algebraic operators that are a) orthogonal to each other and b) antisymmetric in permuting $\hat{A}$ and $\hat{B}$, as follows:

$$\begin{pmatrix} \hat{A} & \hat{B} \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} \begin{pmatrix} \hat{A} \\ \hat{B} \end{pmatrix} = \hat{A}^2 - \hat{B}^2, \tag{G1}$$

$$\begin{pmatrix} \hat{A} & \hat{B} \end{pmatrix} \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix} \begin{pmatrix} \hat{A} \\ \hat{B} \end{pmatrix} = i\left[\hat{B}, \hat{A}\right], \tag{G2}$$

where $\left[\hat{B}, \hat{A}\right] \equiv \hat{B}\hat{A} - \hat{A}\hat{B}$.

Operator $\left[\hat{B}, \hat{A}\right]$ is reminiscent of the canonical commutators in QM, and $\hat{A}^2 - \hat{B}^2$ is of the spacetime interval in SR.

Based on different Pauli matrices, $\hat{A}^2 - \hat{B}^2$ and $\left[\hat{B}, \hat{A}\right]$ constitute a basis for all antisymmetric degree-2–algebraic operators in $\hat{A}$ and $\hat{B}$. Algebra among operators $\hat{A}_j^{\,2} - \hat{B}_j^{\,2}$ ($j = 1, 2, 3, \ldots$) therefore 'parallel' that among $i\left[\hat{B}_j, \hat{A}_j\right]$. For instance, when equation $f_{L.C.}(\_) = 0$ relates operators—as arguments of linear combination $f_{L.C.}(\_)$—

that are each in the form of $\hat{A}_j^{\,2} - \hat{B}_j^{\,2}$, $f_{L.C.}(\_) = 0$ similarly relates all corresponding $i\left[\hat{B}_j, \hat{A}_j\right]$ (and vice versa). Namely,

$$\begin{gathered} f_{L.C.}\left(\hat{A}_1^{\,2} - \hat{B}_1^{\,2},\, \hat{A}_2^{\,2} - \hat{B}_2^{\,2},\, \hat{A}_3^{\,2} - \hat{B}_3^{\,2},\, ...\right) = 0 \\ \Downarrow \\ f_{L.C.}\left(i\left[\hat{B}_1, \hat{A}_1\right],\, i\left[\hat{B}_2, \hat{A}_2\right],\, i\left[\hat{B}_3, \hat{A}_3\right],\, ...\right) = 0. \end{gathered} \tag{G3}$$

The Pauli matrix ($\hat{\sigma}_z$) in Eq. (G1) and that ($\hat{\sigma}_y$) in Eq. (G2) are components of the Pauli vector in isotropic 3D space. The isotropy also leads to Eq. (G3).

In stochastic SR of 1D space, the following equations of operators hold for QM:

$$\hat{\tilde{t}}^2 - \hat{\tilde{r}}^2 = \hat{\tilde{\tau}}^2, \tag{G4}$$

$$\hat{\tilde{E}}^2 - \hat{\tilde{p}}_r^{\,2} = \hat{\tilde{m}}_0^{\,2}. \tag{G5}$$

When without the hat ^, each symbol may refer to the observed value of the corresponding observable if without confusion. Equations (G4) and (G5) accept conjugation between time and energy. (See Appendix B, for why to deny Pauli's theorem [21]).

Differencing Eqs. (G4) and (G5),

$$\left(\hat{\tilde{E}}^2 - \hat{\tilde{t}}^2\right) - \left(\hat{\tilde{p}}_r^{\,2} - \hat{\tilde{r}}^2\right) = \hat{\tilde{m}}_0^{\,2} - \hat{\tilde{\tau}}^2, \tag{G6}$$

suggests

$$\left[\hat{t}, \hat{E}\right] - \left[\hat{r}, \hat{p}_r\right] = (\equiv)\left[\hat{\tau}, \hat{m}_0\right], \tag{G7}$$

per Eq. (G3) and the definitions of tilded (i.e., stochastic) variables [in Eqs. (A3) and (A4)]. [Notice tildes disappear in Eq. (G7).] In addition, characteristic of special-relativistic QM [23],

$$\left[\hat{r}, \hat{p}_r\right] = -\left[\hat{t}, \hat{E}\right] \tag{G8a}$$

$$= +i\hbar\hat{I}, \tag{G8b}$$

where the plus sign is of the prevailing convention in the literature. Equations (G7)–(G8b) generate the 'double-sized' commutator:

$$\left[\hat{\tau}, \hat{m}_0\right] = -2i\hbar\hat{I}. \tag{G9}$$

For an arbitrary but specific quantum state W, the following relation is valid between two conjugate observables $\hat{A}$ and $\hat{B}$ [24]:

$$\Delta(A)\Delta(B) \geq \frac{1}{2}\left|\left\langle\left[\hat{A}, \hat{B}\right]\right\rangle_W\right|. \tag{G10}$$

Combining Eq. (G9) and Ineq. (G10) gives the *proper* uncertainty principle:

$$\left(\tilde{\sigma}_{PP} >\right)\ \Delta(\tau)\Delta(m_0)\ \left(\equiv \sigma_{PP}\right)\ \geq \hbar\,, \tag{G11}$$

in contrast to the (nonrelativistic) Heisenberg uncertainty principle, $(\tilde{\sigma}_{OB} >)\ \Delta(r)\Delta(p_r)$ $(\equiv \sigma_{OB})\ \geq \hbar/2$.

Appendix H: Electron-positron Energy Gap

The energy gap between electron e$^-$ and positron e$^+$ is twice the electron rest-mass m_e [23]. In the mildest e$^-$-e$^+$ pair-production event, e$^-$ 'sees' e$^+$ higher by $2m_e$ in energy, and vice versa, per the charge conjugation.

Below checks Eq. (6)'s [or (D4)'s] validity against this requirement, in the limit of a) $\Delta(c_{1,R})$ vanishes and b) each elementary particle has quasi 'completed' its interactional redshift 'in' its emitting event. Because e$^-$ 'carriers' $\bar{\phi} = 1/2$ from the mildest e$^-$-e$^+$ pair-production event, Eq. (6) predicts the *equivalent* (*pseudo*) relative speed $\left|\langle\beta_R\rangle\right|$ between e$^-$ and the event is $1/\sqrt{3}$. (See Appendix I, for why speed is pseudo.) Per SR's velocity addition rule [10,11], the equivalent (pseudo) velocity $\langle\beta_{+-}\rangle$ of e$^+$ relative to e$^-$ becomes $\sqrt{3}/2$. The relative energy E_{+-} of e$^+$ to e$^-$ is $m_e\left(1-\langle\beta_{+-}\rangle^2\right)^{-1/2}$, so the minimum E_{+-}, namely, the e$^-$-e$^+$ energy gap, turns out $2m_e$.

Both $\langle\beta_R\rangle$ and $\langle\beta_{+-}\rangle$ in here are nominal parameters—instead of velocities in SR. The justification of the above calculation is a) Eq. (12) holds in between mass entities [i.e., a) between the event and either the resulting e$^+$ or e$^-$, and b) between the resulting e$^+$ and e$^-$] in GR and QM and b) Eq. (12) is equivalent to Eq. (6) in stochastic SR.

Appendix I: $\langle\beta_R\rangle$ as Pseudo Observable

As an "observable," $\langle\beta_R\rangle$ violates the principle of relativity, for the following reasons.

Being a single event, the generalized observer must (locally) 'own' its observables. The observer 'encounters' the elementary particle, not the concerned particle-emitting event (along with its $\langle\beta_R\rangle$). For being nonlocal to the observer, $\langle\beta_R\rangle$ cannot be a true (observer-owned) observable.

Second, the numerical reference of an observable ought to be of the event's intrinsic property; as a reference for $\langle \beta_R \rangle$, neither (nominal) stationarity nor the statistical speed of light is a property intrinsic and specific to the event.

Outside SR, $\langle \beta_R \rangle$ is meaningless.

Appendix J: No Observability at Dawn of Time

In the "standard" cosmological model [4,5,11], we have

$$1+z=\frac{a(t_{C0})}{a(t_C)}, \tag{J1}$$

where z is the cosmological redshift, $a(t_C)$ the Friedmann scale factor of *then* (at cosmic-time t_C), and $a(t_{C0})$ that of *now* (at cosmic-time t_{C0}). Along with Eq. (J1) and $a(t_{C0})=1$, Eq. (12) turns into

$$\tilde{\phi}(t_C)=\frac{2}{a(t_C)^2+a(t_C)^{-2}}, \tag{J2}$$

showing how the observability of the cosmic history has been fading away over cosmic-time and approaching zero, as t_C [and $a(t_C)$] (backward) approaching zero. Equation (J2) indicates 0^+ observability expected of the extreme onset of the Big Bang, agreeing nothing 'before' it is observable.

Appendix K: ROC in GR

Per Eqs. (D4)–(D6),

$$\left(1+\langle \beta_R \rangle^2\right)\left(1+\bar{\phi}\right)=2 \tag{K1}$$

holds in the limit of zero $\Delta(c_R)$. [Notice Eq. (K1) involves $\bar{\phi}$, not $\tilde{\phi}$.] Namely, the law of ROC is inherent to 'classical' SR (which this limit is characteristic of)—so is the law, in the form of Eq. (12), to GR, because 'classical' SR anchors GR, *within* the limit per se.

On the other hand, 'classical' SR shows flaws in accommodating quantum uncertainties [see Appendix C and comments after Eq. (4)]. In this sense, stochastic SR anchors GR (and QM), well before reaching the limit of zero $\Delta(c_R)$. The law of ROC [in the form of Eq. (12)] is inherent to quantum gravity and, in the limit of zero local $\Delta(c_R)$, to GR.

Appendix L: Correction on Star Magnitude

In astronomy, a cosmic object's observed-magnitude $\underline{m}$ (underscored for distinction from mass m) relates to its absolute magnitude $\underline{M}$ [5]:

$$\underline{m} = \underline{M} + 2.5\log_{10}\left(\frac{F_{\underline{M}}}{F}\right), \tag{L1}$$

where F is the observed flux from the object, and $F_{\underline{M}}$ the expected observed flux as if the same object were ten parsec (pc) from us, which is the defining condition of $\underline{M}$. Both F and $F_{\underline{M}}$ follow the inverse-square law, with the luminosity distance corrected with the GR-based cosmological model [4], which however presumes no ROC in *our* observation.

To reflect the ROC, Eq. (L1) becomes

$$\underline{m} = \underline{M} + 2.5\log_{10}\left(\frac{F_{\underline{M}\times}\,\tilde{\phi}(z_{10\text{ pc}})}{F_{\times}\,\tilde{\phi}(z)}\right) \tag{L2a}$$

$$\cong \underline{M}_{\times} + 2.5\log_{10}\left(\frac{F_{\underline{M}\times}}{F_{\times}\,\tilde{\phi}(z)}\right) \tag{L2b}$$

$$= \underline{m}_{\times} - 2.5\log_{10}\left(\tilde{\phi}(z)\right), \tag{L2c}$$

with subscript $\times$ indicating 'as if no ROC associated only with *our* observation,' and $\tilde{\phi}$ being the multiplicative correction for the ROC. The $\cong$ sign in Eq. (L2b) is practically an $=$ sign, as $\tilde{\phi}(z_{10\text{ pc}})$ is exceedingly near value one and barely affects the scale of the absolute magnitude—so $\underline{M}_{\times}$ substitutes for $\underline{M}$. From Eq. (L2b) to (L2c) is an application of the $\times$-version of Eq. (L1). Without our prior awareness of the ROC effect, the current literature has mistaken $F_{\times}$ for F, $F_{\underline{M}\times}$ for $F_{\underline{M}}$, and then $\underline{m}_{\times}$ for $\underline{m}$.

Combining Eqs. (12) and (L2c) gives

$$\underline{m}(ROC;\ z) = \underline{m}(No\ ROC;\ z) + 2.5\log_{10}\left(\frac{(1+z)^2 + (1+z)^{-2}}{2}\right), \tag{L3}$$

where $\underline{m}(ROC;\ z) \equiv \underline{m}(z)$ and $\underline{m}(No\ ROC;\ z) \equiv \underline{m}_{\times}(z)$.

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