Redshift diminishes observability: Cosmic acceleration is illusion*

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Mainstream cosmology proclaims the cosmic expansion is accelerating, by mysterious "dark energy" accounting for 70% of the cosmos. This paper "decelerates" it to the critical expansion, by reinterpreting cosmological observation data, *free* of parameter fitting—via a relativistic law on how 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 reflects the degree of *resonance in length scale*, between the event and the observer. The law roots in the event-size's being the multiplicative product (measured in $\hbar$) of conjugate uncertainties, as the Heisenberg uncertainty principle implies. Redshift and observability, though each varying with relativity, covary into the law, per the principle of relativity—also per the uncertainty principle herein generalized for relativity. Agreeing with the Barbour 'timelessness,' the law holds in particle physics, evaporates "dark energy," and potentially dissolves two other cosmological enigmas, all without numerical tweak.

Subject Areas: Measurement theory (quantum mechanics) (03.65.Ta), Wave propagation and interactions (04.30.Nk), Dark energy (95.36.+x)

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, 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, observation *probability*—of an event. The law dismisses "cosmic acceleration" [1–3] and returns the cosmos to the critical expansion [4,5], within observational uncertainty.

The most celebrated "evidence of cosmic acceleration" has been the 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.

As a preview, Fig. 1 depicts the law [see Eq. (12)] on how the event observability $\tilde{\phi}$ (via any elementary particle as a medium) decreases from 100% anchored at $z = 0$, down to zero at z '$=$' -1 (extreme of blueshift) or ∞ (extreme of redshift). Therefore, in the universe of general relativity (GR), the observability—or the *effectiveness* of luminosity—of a star drops to 47%, as cosmological redshift z equal to 1; to near zero, as z approaching infinity. In other words, the compromise on the event observability reflects

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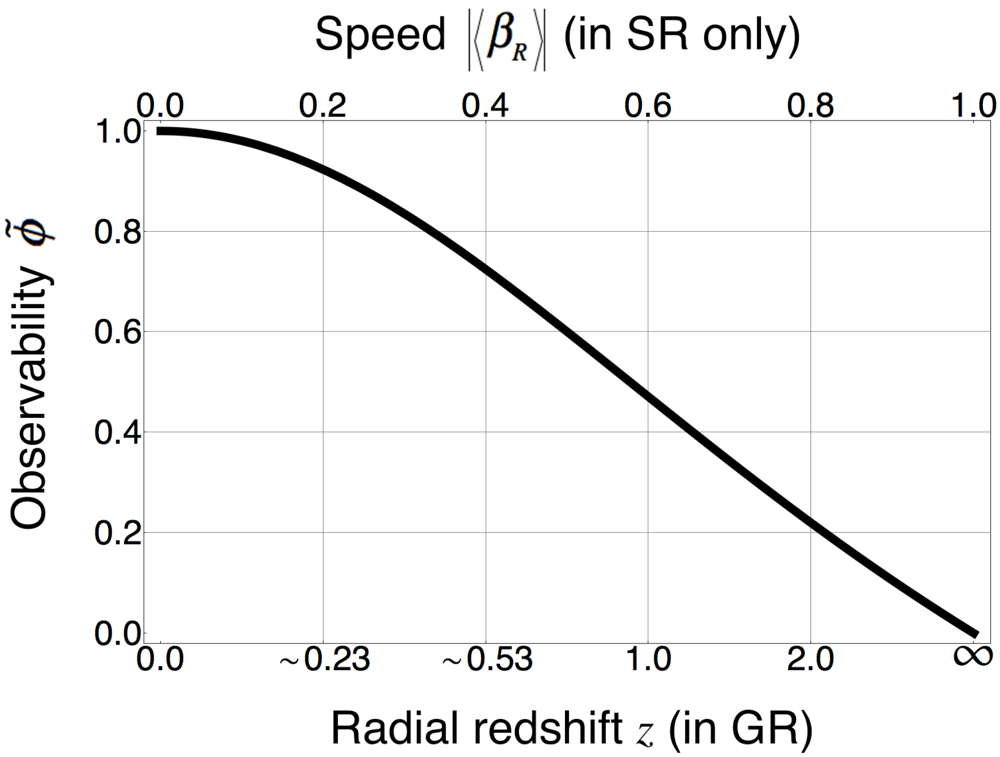

FIG. 1. Functional form of the event's observability $\tilde{\phi}$ (namely, the unitless *efficiency* of the event's intrinsic emission of any kind—after correction for all factors other than redshift, e.g., the event-to-observer luminosity distance):

a) $\tilde{\phi}(|\langle\beta_R\rangle|)$, where $|\langle\beta_R\rangle|$: (0, 1) is the radial speed of the event in (stochastic) special relativity (SR), per Eq. (6), and

b) $\tilde{\phi}(z)$, where z: (0, ∞) is the radial redshift of the event's emission in general relativity (GR), per Eq. (12). For radial *blue*shift z: (–1, 0), $\tilde{\phi}(z)$ is the same curve, but left-right reversed. Both redshift and blueshift diminish the event's observability.

the mismatch between λ and λ_0, agreeing with the common knowledge that λ '=' 0 and ∞ be unobservable (as the blackbody radiation has reminded us). By contrast, behind the "cosmic acceleration," the subliminal belief that the event observability is 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, because, in daily life, we see *light* 'only' 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 circulating electrons' orbit and 'fixed' to the lab (though the electron speed is relativistic).

The law is imperative, because, 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, scaled at the observer, and b) L_{PP} the event's *proper* length, scaled at the event—and virtually at the observer, thanks to the principle of relativity [10–12]. Per the 'new' law, with redshift z being $(L_{OB}/L_{PP}) - 1$, 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.

The twins' relation between redshift z and observability $\tilde{\phi}$ a) surfaces from *stochastic* special relativity (SR), introduced herein as a scaffold, and b) sublimes into a law, by the principle of relativity.

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 observer. 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 it is impartial between any and all pairs 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) the 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') the 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.

Stochastic SR modifies the event observability (to $\tilde{\phi}$, in notation) by further asserting the speed of light shows a) an *a priori* constant expectation-value shared by all event-observer pairs but also b) an uncertainty inherent 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.

II. EVENT NETWORK

In QM, 'event' refers to a fundamental happening, whereas 'observer' to an observation *event*, which constitutes a *generalized* observer (as opposed to a conscious observer, such as us). On top of its usual Einsteinian context in relativity, 'observation' now emphasizes the observer's 'seeing along one dimension (1D)' (see below).

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 event. An observation *event* (i.e., observer) is under multiple subsequent observations, and from one event to a next propagates an elementary particle. A composite particle thus corresponds to a contiguous subsection of the event network.

Events are geometric elements of physical reality, so 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.

As **Postulate 1**, *any event observation is along the radial '1D' space—defined by the event-observer pair—that accommodates the 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 as helicity, onto the 1D [13,14]. The 1D forbids any tangential component *to* the observer. With no event in between the two defining events, the 1D connection differs from its counterpart in classical geometry. The following discussion focuses on the 1D, along 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. 'Classical' SR fails to provide a template for logging incidental (that is, *prestatistical* or raw) data, as sub- and superluminality may and should occur because of 'noise.'

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 a) renormalize the scale of speed by *resetting* the new $\langle c_R\rangle$ to one and then b) update $\Delta(c_R)$, 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.

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

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

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

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

Unlike 'classical' SR, stochastic SR offers every event (as well as mass-carrying particle) life and essence, namely, *proper-time increment $\langle \tau \rangle$ and rest-mass $\langle m_0 \rangle$, both dictating (and being quasi dictated by) the 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 $\Delta(c_{1,R}) \equiv \Delta(c_R)/\langle c_R \rangle$. [As a flaw, owing to $\Delta(c_{1,R})$ '=' 0, 'classical' SR leaves $\langle \tau \rangle$ and $\langle m_0 \rangle$ indeterminate and predicts $\Delta(r) = \Delta(t)$ and $\Delta(p_r) = \Delta(E)$ (see Appendix A, for algebra) for *all* entities, erroneously including (mass-carrying) events and mass-carrying 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 a quantum event,

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

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* in QM.

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*-carrying 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} [$\equiv \Delta(\tau)\Delta(m_0)$] 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, $0 < |\langle\beta_R\rangle|$ (< 1), and $0 < \tilde{\phi} < 1$. Self observing is therefore infeasible, rendering a) $\langle X\rangle\Delta(c_{1,R}) \neq 0$ in Eq. (9) and b) $\tilde{\sigma}_{OB} > \sigma_{OB}$ [$\equiv \Delta(r)\Delta(p_r)$] 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 '$\langle r\rangle = \langle p_r\rangle = |\langle\beta_R\rangle| = 0$,' refers to an approachable but unreachable limit.

IV. SPIN AND EVENT-SIZE

The section verifies Eq. (6), in the triple limit of a) the event is speedless to the observer, b) $\Delta(c_{1,R})$ vanishes [in Eq. (9)], and c) the observed elementary particle from the event has quasi 'completed' its interactional redshift. [Limit 'a)' includes the head-on collision between a particle and its antiparticle, at any same speed to our lab.]

Per Postulates 1 and 2, event-size $\tilde{\sigma}_{OB}$ [in Eq. (8)] reduces to σ_{OB} that equals the 1D projection-magnitude of the particle's total angular momentum $\boldsymbol{J}$ [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.

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, below $\hbar/2$. Owing to never forbidding $\boldsymbol{L}$'s projection 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. [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 $\boldsymbol{L}$'s projection is zero.

A formal derivation (see Appendix G) shows

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

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. As a check, because a) $\sigma_{PP} > \sigma_{OB}$ and b) the smallest nonzero increment in angular momentum is $\hbar/2$, the Heisenberg uncertainty principle $(\sigma_{OB} \geq \hbar/2)$ implies

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

which results from Eq. (10) as well [see Appendix G, Inequality (G10)]. For distinction, we name Inequality (11) the *proper* uncertainty principle.

Consider the *mildest* electron-positron (e^--e^+) pair-production event that is 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^+—leads to the proper e^--e^+ energy gap of $2m_e$, where m_e is the rest-mass common to e^- and e^+ (see Appendix H). *Consistently*, the default '$\tilde{\phi} = 1/2$' is the ratio of a) the electron-spin magnitude $\hbar/2$ (per Postulate 1)—or, equivalently, the greatest lower-bound of σ_{OB} for a speedless event, per the (nonrelativistic) Heisenberg uncertainty principle—over b) the *mildest* σ_{PP}, namely, the greatest lower-bound $\hbar$ of 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; that is, forbidden), $\hbar$ (just discussed), or $2\hbar$. We address the last as follows. Equation (6), with the conservation of linear momentum, predicts $\tilde{\phi} = 1/4$ and $3/4$, for the two resulting entangled particles—the former has $\sigma_{OB} = \hbar/2$, $|\langle\beta_R\rangle| = \sqrt{3/5}$, and $\langle m_0\rangle = m_e$; the latter has $\sigma_{OB} = 3\hbar/2$, $|\langle\beta_R\rangle| = \sqrt{1/7}$, and quasi 'rest-mass $\langle m_0\rangle$' $= 3m_e$ (with the increase due to $\boldsymbol{L}$'s projection magnitude $\hbar$) (see Appendix I). Still, the two $\tilde{\phi}$'s add up to one, as anticipated of a single event that is speedless to two complementary observers. [That $|\boldsymbol{L}|$ must be an integer multiple of $\hbar$ rules out the possibility of $\tilde{\phi} = 1/2$ for both particles if $\sigma_{PP} = 2\hbar$ (refer to Appendix I).]

Equation (6) permits continuous 'tuning' of $\tilde{\phi}$ from such exemplified rational numbers dictated by $\boldsymbol{S}$ and $\boldsymbol{L}$. For instance, when the mildest e^--e^+ annihilation *event* moves [radially (for in 1D) to the observer], its $\tilde{\phi}$ via either one of the two resulting photons becomes smaller than $\hbar/(2\hbar)$. The compromise is in observation *probability*; it retains the particle's helicity and 1D projection of $\boldsymbol{L}$, once observed.

See Section V, for the general meaning of '$\tilde{\phi} = 1$' and fractional $\tilde{\phi}$, as a real (rational or irrational) number; 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 the Doppler relation [10,11] of $\langle\beta_R\rangle$ and z—where $\langle\beta_R\rangle$ is meaningful only between mass-carrying entities, and z is of the massless elementary particle travelling in between. Now that the conception of z is universal per particle-wave duality, 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) the observational uncertainty of a fundamental quantum event and b) that of a composite 'event' spanning, at our choice, a contiguous subsection of the event network. Equation (12) applies to observation of cosmic (composite) events or objects, in the 'universe of stochastic SR' for now [and that of GR (see Section VI)].

The observability $\tilde{\phi}$ of an *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 of the *(referenced) event* from the same physical 'happening' (e.g., e^--e^+ annihilation). For a *given* observed λ, a different (but physical) 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 corresponds to a different choice for the event; the $\tilde{\phi}$ resulting from Eq. (12) becomes of this specific event. [Such disciplined flexibility in defining the event also holds in GR (see below).]

For instance, in (a single) observation of the e^--e^+ annihilation, the event may correspond to one of the two generated photons that has partially fulfilled its interactional (i.e., annihilational) redshift, to an arbitrary but specific extent. The 'partial' event may *further* redshift by z' relative to the observer and is characteristic of a z'-dependent observability $\tilde{\phi}'$ to the observer. By the same token, we, as a *single* observer (from a single direction), get to specify, with freedom, a cosmic event or object as if it had a virtual pair of zero z 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 is the summation over two observers' fractional $\tilde{\phi}$'s that leads to total $\tilde{\phi} = 1$.

VI. TRUE OBSERVABLES

In portraying physical laws, the principle of relativity [10–12] demands 'equivalence' of (i.e., among) all observers. From the anthropic perspective of 'event vs. 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 the observers for a common event $\underline{E}$* (underscored for distinction from energy E), *via its intrinsic property*. Defined earlier, 'observer' refers to the generalized observer, *not* us.

As a single event, the observer (locally) 'owns' its observables v_i (with i being an index). Such local v_i reflect the incoming elementary particle at the observer; they 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 only *implicit* of $R_{\underline{E}O}$ through $v_i(\underline{E},\, R_{\underline{E}O})$.

In notation, the above conception condenses to

$$f_{LAW}\left(v_1,\, v_2,\, v_3,\, \ldots\right) = 0\,, \tag{13}$$

where f_{LAW} is the expression describing the law—prohibiting $f_{LAW}(v_1,\, v_2,\, \ldots,\, R_{\underline{E}O}) = 0$. 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 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 complying with the principle of relativity*—warranting $\tilde{\phi}$ and z may covary into a law (invariant to any physically permissible $R_{\underline{E}O}$). Thereby, Eq. (12) holds in GR, *after we obliterate all the scaffolding context of stochastic SR*—such as $\tilde{\phi}$'s 'anatomy' in terms of Δ(_)'s [for the observer is clueless of $\tilde{r}$, $\tilde{p}_r$, $\tilde{\tau}$, and $\tilde{m}_0$, let alone their Δ(_)'s], Eq. (6) [for $\langle\beta_R\rangle$ is a pseudo observable (see Appendix J)], etc.

Equation (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 K). Equation (12) is essential and 'neutral' to any cosmological model, whether or not involving the Big Bang.

VII. NO 'COSMIC ACCELERATION'

To interface with quantum uncertainties, it is stochastic SR, instead of 'classical' SR, that serves as the cornerstone of GR. Stochastic SR embeds Eq. (12), and therefore so does GR (see Appendix L), along with the (complete) GR-based cosmological model. Because a *complete* physical model need encompass observation *per se* (for interpreting observational data), we must calibrate our cosmic observation with the ROC effect.

Being the major "evidence of cosmic acceleration [1–3]," Fig. 2 illustrates observed-magnitude [5] $\underline{m}$ (underscored for distinction from mass m) vs. redshift z of the Type-Ia supernovae. The current article depicts, in the figure, the ROC-corrected curve (blue solid dots) for the cosmic critical-expansion (CCE):

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

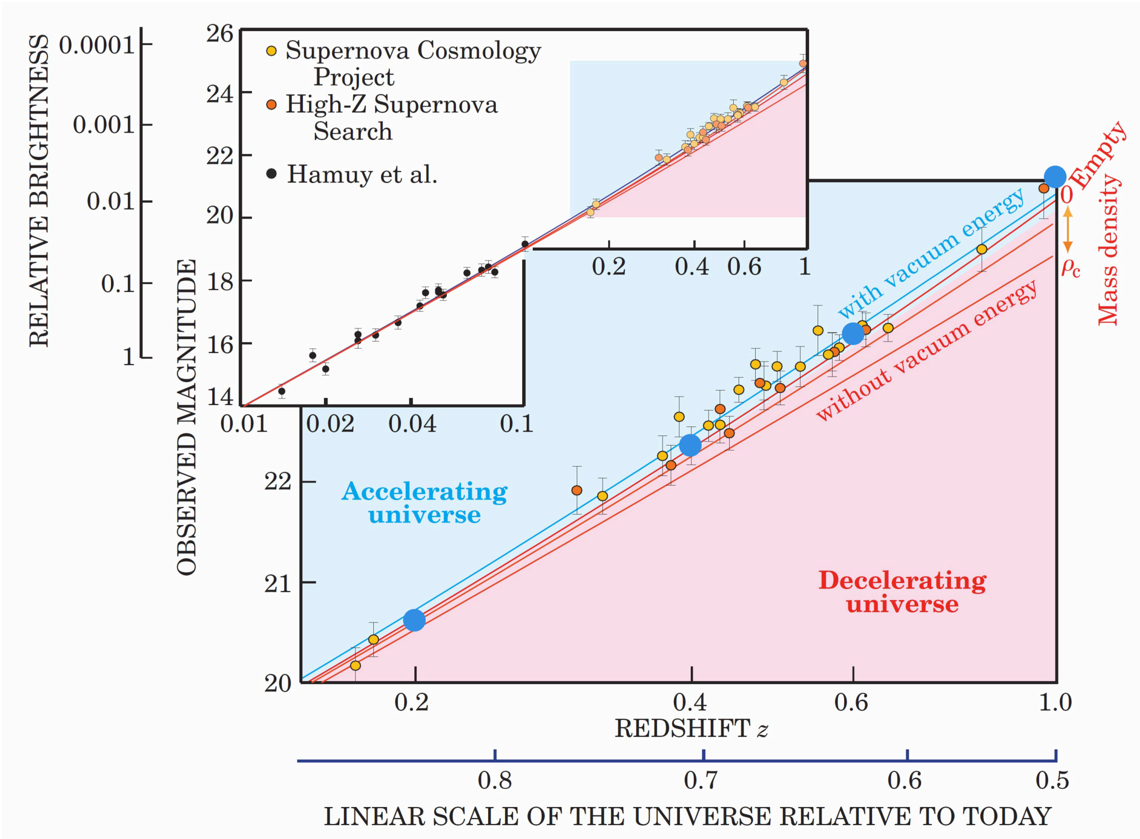

FIG. 2. Observed-magnitude [5] $\underline{m}$ vs. redshift z of Type-Ia supernovae (reproduced with permission from Ref. [1], Copyright 2003, American Institute of Physics). The original caption reads

> "*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 (distances greater than about* 10^9 *light-years), 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.*"

Per Eqs. (12) and (15), the current work adds four blue solid dots—one for each tick-marked z—to indicate the theoretical observed-magnitude $\underline{m}_{CCE}(ROC; z)$ of the Type-Ia supernovae in the cosmic critical-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, showing the cosmos is in the critical expansion, to within observational uncertainty.

where $\underline{m}_{CCE}(No\ ROC;\ z)$ is the CCE curve as if no ROC associated with the photons traversing the universe before our observation terminates them (see Appendix M).

Curve $\underline{m}_{CCE}(ROC;\ z)$ intersects 21 uncertainty bars—of the 28 observational 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 Supernova Search [2], leaving one near miss. The supernovae's data coincide with the rectified cosmic critical-expansion curve, to within observational uncertainty; the supernovae deny the "cosmic acceleration."

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

The law of ROC also seems to dissolve the crisis of, as identified by Ref. [18], missing 400% of hydrogen-atom ionizing photons in observation at cosmological z slightly above 2—where Fig. 1 shows the 400% is $(1-\tilde{\phi})/\tilde{\phi}$ with $\tilde{\phi}(z \cong 2) \cong 0.2$. A recommended further check on the monotonic $\tilde{\phi}(z)$ in Fig. 1 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?

VIII. RELATIVISTIC UNCERTAINTY

Redshift z is Γ–1, where $\Gamma \equiv L_{OB}/L_{PP}$. Equation (12) entails the event's observability *amplitude* ψ in 1D—via the 1D-defining elementary particle (massless or not)—to be

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

where $e^{i\delta}$ is a unitary phase factor. Being a multiplicative factor of the particle's total probability amplitude at the observer, amplitude ψ profiles the degree of resonance in Γ or Γ^{-1}, peaking at Γ = 1. Amplitude ψ leaves intact the particle's helicity and 1D projection of the orbital angular momentum.

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

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

of which the Heisenberg uncertainty principle is the *nonrelativistic* extreme (with $\Gamma = 1$) . The new principle allows relativity, through Γ, to a) squeeze σ_{OB} to below $\hbar/2$ and b) lower the observer-effective vacuum energy in the *expanding* cosmos. Inequalities (11) and (17) are principles of both uncertainty and event-size.

IX. CONCLUDING REMARKS

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 event. Accepting the "cosmic acceleration," namely, denying 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" (which is unphysical and unrecognizable). It is unsurprising that the law of ROC explains away all three cosmic enigmas described in Section VII.

Holding for the cosmological observation and the e^--e^+ interaction, Eq. (16) [with Inequality (17)] 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).

Postulates 0–3 agree with J. Barbour's 'timelessness' [20], and so do the resulting Eqs. (12) and (16)—*after* obliterating stochastic SR (along with 'time') as a scaffold.

Other than experimental tests based on Inequality (17), a recommended check on Fig. 1 is as follows. We may a) create a beam of electrons, narrow in energy distribution but tunable 'up' to 1.2 Mev (for normalized speed of 0.9), to annihilate positrons (e.g., in an electromagnetic trap) 'speedless' in our lab and b) measure how, at a grazing angle to the collision axis, the *effective* photon-emission intensity varies with the annihilation *event's* speed, namely, half the incident electron's speed in here. The measurements are in two opposite directions, one for blueshift, and the other redshift. (The e^--e^+ collider also works if the energy mismatch between the two counter beams is tunable, and therefore so is the annihilation event's speed to the lab.) This may settle the debate.

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APPENDIX A: STOCHASTIC SPECIAL RELATIVITY

Together with Section III (in the main text), this section helps 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:

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

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

where, as a random variable, c_R is the speed of light (i.e., spacetime yardstick) specific to the prestatistical (incidental) event observation, as defined in the main text.

Here begins the derivation. Postulate 2, with the three 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 $\tilde{t}^2-\tilde{r}^2=\tilde{\tau}^2$, by variable definition)

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

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

leaving statistical theory alone to determine parameter a's value.

The definition of standard deviation [15] $\Delta(\_)$ results in

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

where $\langle\_\rangle$ denotes the statistical expectation of '_.' 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 of spacetime, by definition.) In Eq. (A9), $\langle\beta_R\rangle$ must be an *expectation* value—of the event's incidental velocity β_R, 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). $\langle\beta_R\rangle$ must also correspond to the *radial* velocity of the event. (Similar to that of c_R, subscript R reminds β_R is a stochastic random variable.)

Restarting from $\tilde{\tau} = \pm(\tilde{t}^2 - \tilde{r}^2)^{1/2}$ [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 geometric and algebraic 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 $\Delta(c_R)/\langle c_R\rangle$, whatever the unit or the value of $\langle c_R\rangle$ is. 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. Equations (A3) and (A4) thus hold as the basic data-logging format for *pre*statistical (incidental) event *observations*, in stochastic SR.

APPENDIX B: CONJUGATION OF TIME AND ENERGY

As defined in Ref. [21], 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 [22] 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. [21]"

APPENDIX C: 'DEFINITIONS' OF $\langle \tau \rangle$ AND $\langle m_0 \rangle$

With a = 1/2, Eq. (A14) reduces to an (quasi) operational '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 (quasi) operational 'definition' of $\langle m_0 \rangle$:

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

Herein, $\langle \tau \rangle$ and $\langle m_0 \rangle$ must be a) positive for the physical *event* and b) nonnegative for the elementary *particle*. Both $\langle \tau \rangle$ 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. Zero $\Delta(c_{1,R})$ 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 Δ(_) and b) stochastic SR. At the quantum-event level, Δ(_) must correspond to the 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

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

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

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 $\overline{\phi}\equiv\dfrac{\Delta(r)\Delta(p_r)}{\Delta(\tau)\Delta(m_0)}$ or, equivalently, $\dfrac{\Delta(t)\Delta(E)}{\Delta(\tau)\Delta(m_0)}$, where the nonzero numerators together highlights 'classical' (nonstochastic) SR's self-contradiction between nonzero event *volumes* [i.e., $\Delta(t)\Delta(r)$'s; not event-sizes] in spacetime and 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 no standard deviation $\Delta(\_)$ from measurement may ever 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 Eq. (6)'s [or (D4)'s] prediction of $\lim_{|\beta_R|\to 0^+}\tilde{\phi}=1$.

APPENDIX F: 'DISCOVERY' OF HIGGS BOSON

Being an elementary particle, the (spin-0) Higgs boson [23] ought to be structureless. Its "discovery" announced, on 3 July 2012, at the LHC [9] fell short of verification in this regard. Did we mistake a meson (e.g., a top-antitop quark pair) for the Higgs boson [17], rhyming the history, in the 1940s, we mistook pions for the *elementary* mediators between protons? Should it exist as a structureless particle, E. Wigner's seminal analysis of the Lorentz group [16]—which forbids spin-zero elementary (structureless) particles—would be incorrect, so would special relativity (SR). It is improper to celebrate the "discovery," along with SR. Voting does not determine physics.

APPENDIX G: DERIVATION OF $\left[\hat{\tau},\,\hat{m}_0\right]=-2i\hbar\hat{I}$

Applying the (Hermitian) Pauli matrices [24,25] 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, ...) 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. By default, Eqs. (G4) and (G5) accept conjugation between time and energy. (See Appendix B, for why to deny Pauli's theorem [22]).

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 (that is, stochastic) variables [in Eqs. (A5) and (A6)], but now with a = 1/2. [Notice tildes disappear in Eq. (G7).] In addition, characteristic of special-relativistic QM [24],

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

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

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 $\hat{B}$ [25]:

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

Combining Eq. (G9) and Inequality (G10) gives an intrinsically nonrelativistic 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 familiar one, $(\tilde{\sigma}_{OB} >)\ \Delta(r)\Delta(p_r)\ (\equiv \sigma_{OB})\ \geq \hbar/2$. In Section IV, it is through Inequality (G10) that Inequality (G11) implies the factor of two in Eq. (G9).

APPENDIX H: ELECTRON-POSITRON ENERGY GAP

The energy gap between electron e^- and positron e^+ is twice the electron rest-mass m_e [24]. In the mildest e^--e^+ pair-production event, e^- 'sees' e^+ higher in energy by $2m_e$, and *vice versa*, per charge conjugation.

Below is a check on Eq. (6)'s [or (D4)'s] validity against this requirement. In the limit of zero $\Delta(c_{1,R})$, owing to e^- carrying $\overline{\phi} = 1/2$ from the mildest 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 J, 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 of e^+ to e^- is $E_{+-} = m_e\left(1-\langle\beta_{+-}\rangle^2\right)^{-1/2}$, so the minimum E_{+-}, namely, the e^--e^+ energy gap, is $2m_e$.

Both $\langle\beta_R\rangle$ and $\langle\beta_{+-}\rangle$ in here are nominal parameters (instead of velocities in the context of 'classical' SR, which addresses mass-carrying particles resulting from *completed* fundamental interactions). The justification is based on Eq. (12)'s a) validity between mass-carrying entities (i.e., events and mass particles) in GR and QM and b) equivalence to Eq. (6) in stochastic SR.

APPENDIX I: LOOKUP TABLE FOR $\tilde{\phi}$ AND $\langle\beta_R\rangle$

(TABLE I.)

TABLE I. Relation between 'rational $\tilde{\phi}$' and $|\langle \beta_R \rangle|$.

Proper event-size $\tilde{\sigma}_{PP}$ ($\hbar$)	Observable event-size $\tilde{\sigma}_{OB}$ ($\hbar$)	Event observability $\tilde{\phi}$	*Equivalent* speed [a] $|\langle \beta_R \rangle|$	'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
5/2	1/2	1/5	$\sqrt{4/6}$	~ 2.146
	1	2/5	$\sqrt{3/7}$	~ 1.189
	3/2	3/5	$\sqrt{2/8}$	~ 0.732
	2	4/5	$\sqrt{1/9}$	~ 0.414
etc.				

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

APPENDIX J: $\langle \beta_R \rangle$ AS PSEUDO OBSERVABLE

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

First, being a single event, the generalized observer must (locally) 'own' its observables. The observer 'encounters' the elementary particle, not the event (along with its $\langle \beta_R \rangle$). For being nonlocal to the observer, $\langle \beta_R \rangle$ cannot be the (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 K: NO OBSERVABILITY AT DAWN OF TIME

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

$$1 + z = \frac{a(t_{C0})}{a(t_C)}, \tag{K1}$$

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. (K1) and $a(t_{C0}) =$ 1, Eq. (12) turns into

$$\tilde{\phi}(t_C) = \frac{2}{a(t_C)^2 + a(t_C)^{-2}}, \tag{K2}$$

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 (K2) indicates 0^+ observability expected of the extreme onset of the Big Bang, agreeing nothing is observable 'before' it.

APPENDIX L: ROC IN GR

Per Eqs. (D4)–(D6),

$$\left(1 + \langle \beta_R \rangle^2\right)\left(1 + \overline{\phi}\right) = 2 \tag{L1}$$

holds in the limit of zero $\Delta(c_R)$. [Notice Eq. (L1) involves $\overline{\phi}$, 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), even 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 local limit of zero $\Delta(c_R)$, to GR.

APPENDIX M: CORRECTION ON STAR MAGNITUDE

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

$$\underline{m} = \underline{M} + 2.5\log_{10}\left(\frac{F_{\underline{M}}}{F}\right), \tag{M1}$$

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

To reflect the ROC, Eq. (M1) becomes

$$\underline{m} = \underline{M} + 2.5\log_{10}\left(\frac{F_{\underline{M}\times}\ \tilde{\phi}(z_{10\ \text{pc}})}{F_\times\ \tilde{\phi}(z)}\right) \tag{M2a}$$

$$\cong \underline{M}_\times + 2.5\log_{10}\left(\frac{F_{\underline{M}\times}}{F_\times\ \tilde{\phi}(z)}\right) \tag{M2b}$$

$$= \underline{m}_\times - 2.5\log_{10}\left(\tilde{\phi}(z)\right), \tag{M2c}$$

with subscript × indicating 'as if no ROC associated with our observation,' and $\tilde{\phi}$ being the multiplicative correction for the ROC. The ≅ sign in Eq. (M2b) is practically an = sign, as $\tilde{\phi}(z_{10\ \text{pc}})$ is exceedingly close to value one and barely affects the scale of the absolute magnitude—so $\underline{M}_\times$ substitutes for $\underline{M}$. From Eq. (M2b) to (M2c) is an application of the '× version' of Eq. (M1). It is unfortunate 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 (M2c) gives

$$\underline{m}(ROC;\ z) = \underline{m}(No\ ROC;\ z) + 2.5\log_{10}\left(\frac{(1+z)^2 + (1+z)^{-2}}{2}\right), \tag{M3}$$

where $\underline{m}(ROC;\ z) \equiv \underline{m}(z)$ and $\underline{m}(No\ ROC;\ z) \equiv \underline{m}_\times(z)$. Because Type-Ia supernovae are a type of standardizable 'candles' and therefore share a common $\underline{M}$, Eq. (M3) results in Eq. (15), as the cosmic critical-expansion curve in terms of $\underline{m}$ vs. z.

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