Relativistic uncertainty principle to illusory cosmic acceleration & dark energy: Lab-test opportunity[1]

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In the (nonrelativistic) Heisenberg uncertainty principle, the inequality's greater side is the product of two conjugate uncertainties, which, owing to conjugation, represents the *'apparent event-intensity'* specific to the event-observer relativity. The paper shows blue- or redshift z diminishes the product—and thereby lowers the lower bound of the (new) *relativistic* uncertainty principle. Namely, *z compromises the quantum efficiency.* The effect is discernable when we observe events with centers of mass in relativistic motion, which are atypical on Earth, even of particle-antiparticle colliders. Independent of luminosity distance, event-observability is '*apparent* event-intensity' divided by '*proper* event-intensity,' with the denominator being the uncertainty in rest-mass times that in proper-time. Each reflecting the degree of *resonance in length scale* between event and observer, event-observability and z covary into a fundamental law, per the principle of relativity—and per a) the relativistic and b) the *'proper'* uncertainty principle (both herein derived). *Without* numerical fitting, the law holds in particle physics, evaporates illusory dark energy (i.e., "stops cosmic acceleration"), and dissolves other cosmological enigmas, including • "photon underproduction crisis" • "asymmetric quasars." In 2010, the law predicted mainstream cosmology would further suffer illusory "acceleration *on* cosmic acceleration," which then emerged in observation in 2016. As a rarity in cosmology, the law is lab-testable; surprising is we have not finished testing special relativity, for insights in quantum gravity.

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1. Introduction

Per relativity and statistics, the paper identifies a fundamental law explicit in relativistic quantum mechanics (QM) but *implicit* (hidden) in general relativity. The law indicates cosmic acceleration [1–3] (by dark energy) is illusory due to misinterpreted (i.e., mismodeled) observation.

As a caveat, there is no distinct demarcation between observational fact and theory, for there is no "observational fact" without a default interpretation or misinterpretation, and the default is often subliminal. "Against observation" could imply against our subliminal mind only. Cosmic acceleration is an observational "fact" that does *not* warrant truth.

In the Heisenberg uncertainty principle, the inequality's 'greater' side is the (Heisenberg) product of two conjugate uncertainties (of a physical event). Owing to

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conjugation, the product is beyond another uncertainty; it is the event's 'apparent intensity' specific to the event-observer relativity. The paper illustrates blue- or redshift in observation diminishes the Heisenberg product, and thus lowers the lower bound of the *relativistic* uncertainty principle (herein introduced). Deeming Heisenberg's original principle relativistic is a consequential mistake.

Redshift z as a variable is $(\lambda/\lambda_0)-1$, ranging the interval $(-1, \infty)$, where λ is the observed (or apparent) wavelength at the observer, and λ_0 the corresponding proper wavelength at the wave-emitting event. Herein, λ is an abbreviation of $\langle\lambda\rangle$; λ_0 of $\langle\lambda_0\rangle$. Unless otherwise stated, 'redshift' refers to the phenomenon of z forward ranging $(0, \infty)$; 'blueshift' backward ranging $(-1, 0)$.

As a law, redshift or blueshift compromises the event's apparent intensity and thus observability (namely, observation *probability*), regardless of the event being fundamental or composite. We dub this phenomenon "relativistic observability compromise" (or ROC, for short). The observability is the *relativistic quantum efficiency* for the particle-wave vectoring from event to observer. The efficiency is of the event-observer pair, *not* of the observer (or 'detector') per se in the conventional sense.

The apparent *dimming* effect has deceived us to believe the cosmic objects were *farther* than expected, "owing to mysterious acceleration" (as a theoretical convenience). The law of ROC dismisses "cosmic acceleration" [1–3] and returns the cosmos to the critical expansion [4,5], which involves no contribution from the vacuum energy, to within present 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 vacuum-energy or dark-energy density Ω_Λ. For correlation, other "supporting evidence" {such as from the cosmic microwave background (CMB) [7], etc. [8]} also roots in the same parameter-space featuring Ω_Λ. While welcoming Ω_Λ , we are "solving" the mystery by creating another. It is judicious to recognize phenomenological correlation unnecessarily implies physical causation, particularly when correlating anything whose existence is in doubt.

A numerical preview of the law follows. The net quantum efficiency of observing the event (that is, observing the event's luminosity in emitting any elementary particles) is proportional to $\tilde{\phi}(z)$ times $\zeta_{\mathrm{D}}\left[\lambda(\lambda_0, z)\right]$, where a) $\zeta_{\mathrm{D}}(\lambda)$ is the observer or detector's quantum efficiency in the usual sense and b) $\tilde{\phi}$: $[0, 1]$ the *relativistic quantum efficiency*, or redshift-compromised effectiveness. $\tilde{\phi}(z)$ is *independent* of luminosity distance but, beyond our everyday experience, dependent on z . The more blue- or redshifted the particles (or particle-waves) appear, the lower the probability to capture them. Figure 1 depicts how $\tilde{\phi}$ decreases from 100% [with no blue- or redshift $(z=0)$] down to zero at the extreme of blueshift $(z\to -1^+)$ or redshift $(z\to\infty)$. For instance, in special relativity (SR), a 100-lumen bright lightbulb, moving away from (or toward) us at half the speed of light, 'dims' to us—but *not* in itself—to of a stationary 60-lumen lightbulb. Likewise, in the universe of general relativity (GR), a star 'dims' to us—not in itself—to 47%, as its redshift z reaches 1.

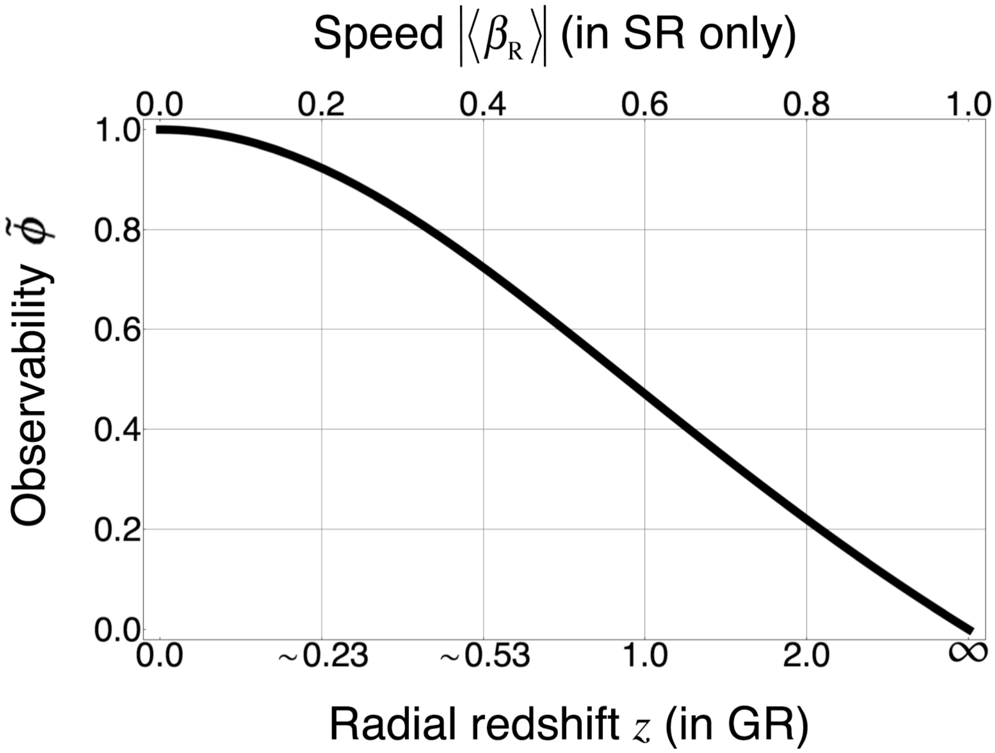

Figure 1. Blue- and redshift diminish event's relativistic observability $\tilde{\phi}$, namely, the *relativistic quantum efficiency* in observing the event. Independent of the event-to-observer luminosity distance, $\tilde{\phi}$ is the *observation-effectiveness* of the event's luminosity, in emission of any elementary particle(s). In (stochastic) special relativity (SR), $\tilde{\phi}$ varies with the radial speed $|\langle \beta_R \rangle|$ (upper abscissa) of the event, per equation (6). In general relativity (GR) (and SR), $\tilde{\phi}$ varies with the radial redshift z: $(0, \infty)$ (lower abscissa) of the event's emission, per equation (12) after generalized in section 6. For the radial blueshift z: $(-1, 0)$, $\tilde{\phi}(z)$ shows the same curve, only left-right reversed. Over the entire domain z: $(-1, \infty)$, $\tilde{\phi}(z)$ —peaking at $z = 0$ —represents the *universal resonance* in the relative length-scale between the event and the generalized observer (which is a subsequent event).

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. Even in the Large Hadron Collider (LHC; between relativistic protons and antiprotons) [9], the *centers of mass* of the collision *events* are speedless to the lab. As a reminder, our observations of 'relativistic events'—not stationary events ejecting relativistic particles—have been close to none, though SR has been a centenarian.

On the other hand, the law is imperative. In measuring wavelength, we have neither resolution for zero nor capacity for infinity (∞), that is, we cannot observe the extremes of blue- and redshift. The compromise on $\tilde{\phi}$ mirrors 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 exemplified. By contrast, behind "cosmic acceleration," the subliminal belief that $\tilde{\phi}$ is 100% (i.e., z- independent) fails the sanity check.

In GR, the ratio λ/λ_0 *equals* $L_{\text{OB}}/L_{\text{PP}}$, where a) L_{OB} is the event's length-scale (in the event-observer direction) *observed* (at the observer), and b) L_{PP} the event's length-scale that is *proper* at the event—and virtual-equivalently at the observer, thanks to the principle of relativity (PoR) [10–12]. With redshift z being $\left(L_{\text{OB}}/L_{\text{PP}}\right)-1$, the "new" law shows $\tilde{\phi}$ reflects the degree of <u>*resonance in length-scale*</u>, between the (*proper-observer*–scaled) event and the (*proper-event*–scaled) observer (i.e., the default '*proper-observer*–scaled observer,' thanks to the PoR).

Thereby, the law of ROC must be intrinsic to GR—but it is implicit, in that a) the law is both quantum mechanical and relativistic in nature and b) GR represents the geometric nonquantum limit. Though expected to manifest the ROC effect, GR per se cannot express the quantum aspect of the law. So, before maturing quantum gravity, the paper fishes out the law by starting with SR's statistical characteristics for a') QM is statistical and b') QM and SR must agree on statistics. Under the premise, we get to escape the inertia of GR algebra in addressing cosmological enigmas for now. Namely, we do accept all the luminosity distance calibration per GR, in the existing cosmological model, and address only what is missing.

The formal argument begins with **Postulate 0:** *The <u>generalized-event's relativistic observability</u> is the occurrence probability of the 'structureless event-to-observer vectoring particle' (i.e., an elementary particle) at the <u>generalized observer</u>* (see section 2 for definition). *The vectoring particle manifests the event's relativistic observability, which equals*

$$\frac{Observable\ (i.e.,\ apparent)\ event\ intensity}{Proper\ (i.e.,\ intrinsic)\ event\ intensity},$$

with the event-intensities in unit of $\hbar$.

In current relativistic QM, the *observable* event-intensity σ_{OB} is $\Delta(r)\Delta(p)$, and the *proper* event-intensity σ_{PP} (in the Planck units) is $\Delta(\tau)\Delta(m_0)$, where 'proper' means 'zero relativity,' r is the event's position increment, τ proper-time increment, p *canonical* momentum, m_0 proper- or rest-mass, and $\Delta(\_)$ denotes the 'uncertainty or standard deviation' [13]—all defined as a 'projection' onto the nominal 1D vectored out by the particle. Such 1Ds synthesize the 3D, which justifies the 1D projections, in return. At face value, the event-fraction $\sigma_{\text{OB}}/\sigma_{\text{PP}}$ $\left(\equiv\bar{\phi}\right)$ becomes the event (relativistic) observability. [An analogy in the 1D harmonic oscillator is: The state *intensity* $\Delta(r)\Delta(p)$ of the *n*-th eigenstate equals $(n + ½)\hbar$, where *n* is a nonnegative integer. It is heuristic to ruminate why the unit $\hbar$ for angular momentum in 3D squeezes into the 1D scenario.]

In addition, we present stochastic SR (as a scaffolding to justify the law of ROC in GR) that asserts the speed of light manifests not only a) an a priori constant *expectation value* common to all event-observer pairs but further b) an uncertainty inherent and specific to each event-observer pair. (In notation, $\overline{\phi}$ introduced above is the event relativistic observability in SR; $\tilde{\phi}$ the modified counterpart in stochastic SR.) Being a cornerstone of Einstein's SR, the statement that the speed of light is constant refers to the expectation value of the speed of light, not incidental (i.e., not prestatistical) measurements of the speed of light. We have been by far oblivious of the pivotal distinction.

It is the definition of event's relativistic observability, along with the uncertainty in the speed-of-light measurement, that unveils the law of ROC in stochastic SR and then in relativistic QM. Second, it is the principle of relativity that sublimes the law of ROC into an integral (but so far unnoticed) aspect of GR.

For a quick review, sections 7 (No cosmic acceleration) and 8 (Concluding remarks) may serve as an extension of the introduction.

2. Preliminary event network

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

As a footnote, elementary particles exist only 'on observation.' Their existence is virtual before being observed; in this sense, they are virtual fragments from their source events.

No elementary particle reveals its identity alone, in that its existence means already in interaction with, and being part of, both an event in disintegration and an observer in creation. As a model, reality is an evolving 3D network among observation events, each of which terminates one set of elementary particles and then emits another set—*entangled* by the emitter.

In the 'preliminary' 3D network defined herein, any event has a *proper* angular momentum $\boldsymbol{J}_{\mathrm{PP}}$, resulting from the vectorial sum of the incoming, event-forming particles' angular momenta $\boldsymbol{J}_i$ (relative to the observer), where *i* is the particle index. The event's wavefunction represents a coherent or entangled state (which may be delocalized in space).

Any event is under subsequent observations. The first of the observations a) 'determines' the first observed particle, along with its $\boldsymbol{J}_{i\,(=1)}$, per the event's initial wavefunction, and b) results in the remainder wavefunction of the yet-to-be-observed or -determined other particle(s). Likewise, the second observation determines the second, per the first remainder wavefunction; and so on. On exhausting the remainder, the $\boldsymbol{J}_{\mathrm{PP}}$ of the event resurfaces in value as the sum of the newborn $\boldsymbol{J}_i$.

Each resulting $\boldsymbol{J}_i$ is 'tail-on' or 'head-on' to its (upcoming) observer, in terms of $\boldsymbol{J}_i$'s on-axis projection; namely, $\boldsymbol{J}_i$ projects either $-|\boldsymbol{J}_i|$ or $|\boldsymbol{J}_i|$. This is an operational definition of the event network, for then each observer may, in principle, infer its $\boldsymbol{J}_{\mathrm{PP}}$, per all the incoming 'on-axis $\boldsymbol{J}_i$.' If the projection is in between $-|\boldsymbol{J}_i'|$ and $|\boldsymbol{J}_i'|$, of an indeterminate $\boldsymbol{J}_i'$ greater than the pragmatically defined $\boldsymbol{J}_i$ in magnitude, the observer would lose the *self*-contained perspective.

The above picture agrees with the following *experimental* observations [14,15] on $\boldsymbol{J}_i = \boldsymbol{L}_i + \boldsymbol{S}_i$, where $\boldsymbol{L}_i$ is the particle's orbital angular momentum, and $\boldsymbol{S}_i$ the intrinsic spin. Upon measurement, a particle reveals an $\boldsymbol{L}_i$ about the propagation (i.e., observation) axis, with the on-axis projection being *either* $-|\boldsymbol{L}_i|$ or $|\boldsymbol{L}_i|$—or zero for a plane wave. In parallel, each $\boldsymbol{S}_i$ projects *either* $-|\boldsymbol{S}_i|$ or $|\boldsymbol{S}_i|$, but with zero excluded *per SR* (see section 4 and appendix F)], whether the elementary particle is massless or not. For instance, a single photon's spin never appears 'orthogonal' to the propagation axis; the resulting helicity is either $-\hbar$ or $\hbar$.

Through disentanglement, a particle 'propagates' from event to observer, in the event network. A composite event (or particle) corresponds to a contiguous subsection of the network.

As a recap, **Postulate 1** states *any event observation is along the '1D'—defined by the event-observer pair—that accommodates either* $-|\boldsymbol{J}|$ *or* $|\boldsymbol{J}|$ *as the projection of the elementary particle's total angular momentum* $\boldsymbol{J}$ *relative to the observer.* Observation is *radial*. With no event in between the two defining events, the 1D differs from its counterpart in classical geometry. We will focus on the 1D, with the new connotation.

In current relativistic QM, $|\boldsymbol{J}_i|$ equals the 'fiducial observable event-intensity' σ_{OB} (which is specific and inherent to the 1D in the 3D network), and $|\boldsymbol{J}_{\mathrm{PP}}|$ equals the 'fiducial proper event-intensity' σ_{PP} . [Defined in section 1, $\sigma_{\mathrm{OB}} = \Delta(r)\Delta(p)$ and $\sigma_{\mathrm{PP}} = \Delta(\tau)\Delta(m_0)$.]

As a clarification in nomenclature, σ_{OB} and σ_{PP} are 'fiducial' event-intensities, for being valid in a fiducial limit discussed in section 4; σ_{OB} and σ_{PP} signify the limit so far most familiar to us. The '(general) observable event-intensity' $\tilde{\sigma}_{\mathrm{OB}}$ and the '(general) proper event-intensity' $\tilde{\sigma}_{\mathrm{PP}}$ (both defined in section 3) may concurrently deviate from their fiducial counterparts (σ_{OB} and σ_{PP}), depending on how the generalized observer or we (as conscious observers) subjectively define the event of concern (see section 5).

3. Mass and observability

Per the conjugation reflected by the Heisenberg uncertainty principle, events in spacetime are never volumeless mathematical points, for instance, not as required of the (fictitious) speed-of-light measurements that would, from a 'point source' to a 'point detector,' always reproduce the speed-of-light constant. Sub- and superluminality must occur owing to quantum noise. It is unsurprising that 'classical' SR offers *no* template for logging incidental (i.e., raw and *prestatistical*) data, because constancy in the speed of light is an undue constraint (to raw data).

A physical constant is an a priori mathematical constant, but with uncertainty in observation. Per incidental (prestatistical) measurement, the speed of light is a *random (stochastic) variable* c_{R} , in that, on further c_{R} measurements, we can thereby renormalize the scale of speed, that is, to *reset* $\langle c_{\mathrm{R}} \rangle$ to one [and then update $\Delta(c_{\mathrm{R}})$, etc.], where $\langle \_ \rangle$ is the statistical expectation value. It is due to our postmeasurement rescaling and *theoretical reassertion* that $\langle c_{\mathrm{R}} \rangle$ $(\equiv c)$ equals one. (In the similar sense, $\hbar$ is 'constant.')

The rest of the section addresses the aforementioned '1D.' For logging incidental data, SR becomes *stochastic* (see appendix A, for derivation):

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

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

in the Planck units, where t is time increment, and E energy. Equations (1) and (2) are based on **Postulate 2:** *Being a random variable, speed-of-light* c_{R} *serves as the spacetime yardstick—namely, with the provision that* $\tilde{r}/\tilde{t} = \tilde{E}/\tilde{p} = 1$, *or* $r/t = E/p = c_{\mathrm{R}}$, *'as'* $\tau = m_0 = 0$ *—specific to the incidental (prestatistical) event observation* [which the random (tilded) dynamic variables defined in (1) and (2) collectively describe]. The random dynamic variables describe the (incidental) *event observation*, not just the event. Equations (1) and (2) also follow two default premises: a) convergence of stochastic SR to 'classical' SR, in the non-QM limit, and b) $\tilde{t}$-$\tilde{E}$, $\tilde{r}$-$\tilde{p}$, and $\tilde{\tau}$-$\tilde{m}_0$ conjugation (see appendix B). The two equations represent beyond a unit change of variables, which requires a conversion constant (e.g., c), not a random variable.

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

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

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

where $\Delta(c_{1,\mathrm{R}}) \equiv \Delta(c_{\mathrm{R}})/\langle c_{\mathrm{R}} \rangle$. The $\Delta(_)$s are characteristic of the event-observer pair, and, as a caveat, they are *not* arbitrary as classical measurements may have implied. As operational definitions of $\langle \tau \rangle$ and $\langle m_0 \rangle$, equations (3) and (4) do not result in arbitrary values. A trivial implication of (4) is: Under a fixed value of $\left[\Delta(p)\right]^2 - \left[\Delta(E)\right]^2$, the more massive the light source is, the more precise the speed-of-light measurement.

Per (3) and (4), 'classical' SR owing to zero $\Delta(c_{1,\mathrm{R}})$ either a) leaves $\langle \tau \rangle$ and $\langle m_0 \rangle$ indeterminate or b) predicts $\Delta(r) = \Delta(t)$ and $\Delta(p) = \Delta(E)$ (see figure 2, for a geometric description) for *all* physical entities, erroneously including (mass-carrying) events and mass particles. [Note both $\Delta(r)=\Delta(t)$ and $\Delta(p)=\Delta(E)$ apply only to massless particles.]

On the other hand, gravity physics mandates the speed of light deviate from constancy in observation if and only if gravity appears [11,12,14], that is, in observing any (mass-carrying) quantum event,

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

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

Equations (1) and (2) lead to the <u>law of ROC</u> in stochastic SR (see appendix D):

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

$$\langle\beta_{\mathrm{R}}\rangle\equiv\frac{\langle\tilde{r}\rangle}{\langle\tilde{t}\rangle}\left(=\frac{\langle r\rangle}{\langle t\rangle}\right)=\frac{\langle\tilde{p}\rangle}{\langle\tilde{E}\rangle}\left(=\frac{\langle p\rangle}{\langle E\rangle}\right), \tag{7}$$

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

where $\tilde{\phi}$ is the event's hit-or-miss (relativistic) observability, and each constituent $\Delta(\tilde{X})$ in (8) is

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

In terminology, $\tilde{\sigma}_{\mathrm{OB}}$ is the observable (apparent) event-intensity, and $\tilde{\sigma}_{\mathrm{PP}}$ the proper (intrinsic) event-intensity. As another random variable, β_{R} is the *event*'s incidental velocity, relative to the immediate follow-on *mass* entity, which is either a) the observer to whom the event emits a massless elementary particle or b) the event-to-observer elementary particle carrying a (nonzero) rest-mass. Via (9), $\tilde{\sigma}_{\mathrm{PP}}$ [defined in (8)] becomes proper of—because $\Delta(c_{1,\mathrm{R}})$ is characteristic of—the *event observation*; in comparison, (tilde-free) 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 $\Delta(c_{1,\mathrm{R}})$ not operationally defined.

Equation (6), with $\Delta(\_)>0$, enforces $\langle\beta_{\mathrm{R}}\rangle\neq 0$ (see appendix E), namely, $0<\left|\langle\beta_{\mathrm{R}}\rangle\right|$ (<1) —and $0<\tilde{\phi}<1$. Self observation is therefore infeasible, rendering a) $\langle X\rangle\Delta(c_{1,\mathrm{R}})\neq 0$ in (9) and b) $\tilde{\sigma}_{\mathrm{OB}}>\sigma_{\mathrm{OB}}$ $\left[\equiv\Delta(r)\Delta(p)\right]$ and $\tilde{\sigma}_{\mathrm{PP}}>\sigma_{\mathrm{PP}}$. Besides, $\Delta(c_{1,\mathrm{R}})$ 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 $\langle r\rangle$, $\langle p\rangle$, and $\left|\langle\beta_{\mathrm{R}}\rangle\right|$ all equal to zero, refers to an approachable but unreachable limit.

4. Spin and event-intensity

Angular momentum and event-intensity are both in unit of $\hbar$. We expect their accountings are identical, in 'classic' observation of events whose centers of mass are quasi-stationary to the observer.

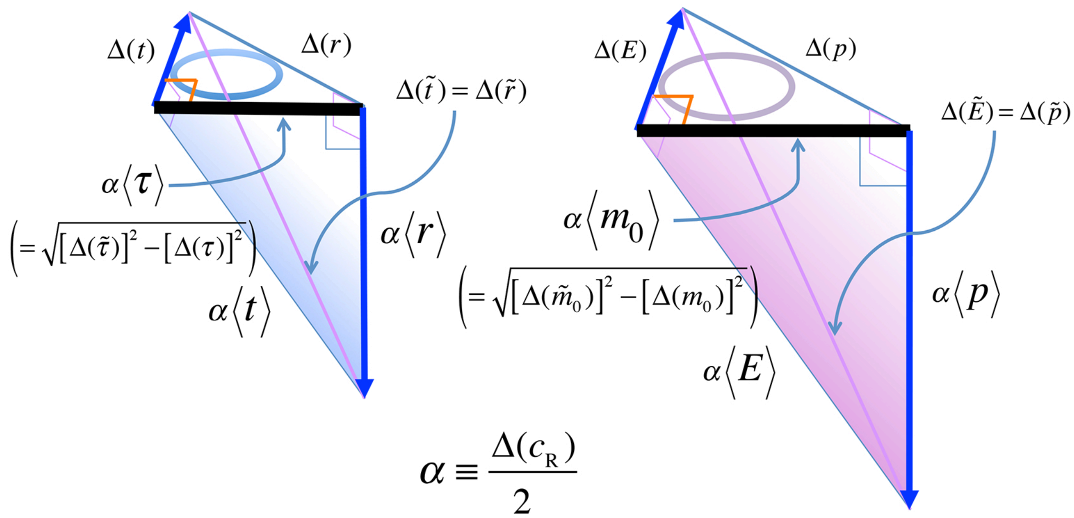

Figure 2. Vital to special relativity (SR) are the a priori constant *expectation value* $c\ \left(\equiv\langle c_R\rangle\right)$ of the speed of light *and* the event-observer–specific *standard deviation* $\Delta(c_R)$. Observational statistics demands their coexistence. Featuring nonzero $\Delta(c_R)$, stochastic SR leads to the two conjugate tetrahedrons as shown, with a) all facets being right-triangular and b) $\alpha\ \left(=\Delta(c_R)/2\right)$ being the common scaling factor for SR's two fundamental equations (represented by the two shaded front facets) and fundamental uncertainties. 'Classical' SR presumes zero $\Delta(c_R)$ (or α), which forces $\Delta(t)=\Delta(r)$ and $\Delta(E)=\Delta(p)$, both valid only for massless entities, *erroneously* hold for mass entities (that is, as $\langle\tau\rangle \neq 0$ and $\langle m_0\rangle \neq 0$,)—as evidenced by the two top facets vanishing into line segments, which are generally untrue for a mass entity. Stressing the operational definition for the speed of light, stochastic SR rectifies the self-inconsistency in 'classical' SR.

This section verifies (6) in particle physics—in the fiducial limit of three premises: a) $\Delta(c_{1,R})$ vanishes [in (9)], b) the observed elementary particle has quasi 'completed' its interactional redshift *in* the event under observation, and c) the event is quasi speedless to the observer. Per Postulates 1 (see section 2) and 2 (see section 3), the event-*intensity* $\tilde{\sigma}_{\mathrm{OB}}$ in this limit reduces to σ_{OB} , that is, to the particle's on-axis $|\boldsymbol{J}|$ $(=|\boldsymbol{L}+\boldsymbol{S}|)$ [14,15]. Relativistic observability $\tilde{\phi}$ now becomes a rational number (per quantization of angular momentum).

In this nonrelativistic limit, an *elementary* (structureless) particle free of $\boldsymbol{L}$ and $\boldsymbol{S}$ would violate the (nonrelativistic) Heisenberg uncertainty principle (i.e., $\sigma_{\mathrm{OB}} \geq \hbar/2$), for squeezing $\tilde{\sigma}_{\mathrm{OB}}$ $\left(>\sigma_{\mathrm{OB}}\right)$ and hence σ_{OB} to zero (that is, to below $\hbar/2$). Therefore, always permitting any elementary particle's on-axis $\boldsymbol{L}$ to be zero (i.e., a plane wave), *Nature prohibits spin-zero elementary particles*. This conclusion agrees with Wigner's seminal analysis on the Lorentz group [16,17] of SR, implying the "discovered (spin-zero) Higgs boson" is not 'elementary' (see appendix F). An elementary particle (massless or not) must manifest a nonzero $\boldsymbol{S}$ (*and* thus render a nonzero on-axis projection of $\boldsymbol{S}$) [16,17], to warrant its (nonzero) observability in case $\boldsymbol{L}$ is zero.

Per a) the Pauli vector in the isotropic 3-space and b) the spacetime metric, formal derivation shows (in appendix G) the commutator between proper-time and rest-mass is "double-sized:"

$$\left[\hat{\tau},\, \hat{m}_0\right] = -2\mathrm{i}\hbar\hat{I} \quad (\text{not } -\mathrm{i}\hbar\hat{I}\ ), \tag{10}$$

with ^ labeling quantum operators and $\hat{I}$ being the identity operator. (The double-sizing has been missing in the literature.) Equation (10) results in [through (G.11)] the 'proper' uncertainty principle:

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

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

Consider, in the triple limit, the electron-positron (e^--e^+) pair-production event resulting from collision of two (spin-1) photons with *no* relative $\boldsymbol{L}$—which leaves $\sigma_{\mathrm{PP}} = 0$ (unobservable; forbidden), $\hbar$, or $2\hbar$. Further suppose the two observers (of e^--or-e^+) are collinear with the event. Such premises entail the two $\tilde{\phi}$s (if nonzero) add up to one. (Recall, per premise 'b,' the particles have quasi 'completed' the interactional redshift.)

In the case of $\sigma_{\mathrm{PP}} = \hbar$ (namely, of the *mildest* pair-production), the default observability of $\tilde{\phi} = 1/2$ to each observer turns out to be the expected ratio of $\hbar/2$ over $\hbar$. In here, a) numerator $\hbar/2$ is the electron-spin magnitude (the lowest nonzero value permitted by Postulate 1) or, equivalently, the mildest possible σ_{OB} among all speedless events, per the Heisenberg uncertainty principle; b) denominator $\hbar$ is the mildest possible σ_{PP}, per the 'proper' uncertainty principle [i.e., (11)]. Moreover, equation (6) helps confirm the default $\tilde{\phi}$ of $1/2$ to each observer indeed corresponds to the e^--e^+ energy gap being twice the rest-mass m_{e} of e^- (see appendix H).

In the case of $\sigma_{\mathrm{PP}} = 2\hbar$, equation (6) implies two possibilities in paring $\tilde{\phi}$s (see table 1) to two observers; one is $1/2$-and-$1/2$, and the other is $1/4$-and-$3/4$. And (6) shows $\tilde{\phi} = 1/2$ would force σ_{OB} ($= \tilde{\sigma}_{\mathrm{OB}}$, for now) $= \hbar$ (see table 1)—which violates the requirement that the projection magnitude of $\boldsymbol{L}$ be an integer multiple of $\hbar$, and that of $\boldsymbol{S}$ (due to e^- or e^+) be a half-integer. Namely, equation (6) predicts only $1/4$-and-$3/4$ can happen, from the two originally entangled particles.

Table 1. Relations among 'rational event-intensities,' $\tilde{\phi}$, $\left|\langle\beta_{\mathrm{R}}\rangle\right|$, and z.

Proper event-intensity $\tilde{\sigma}_{\mathrm{PP}}$ ($\hbar$)	Observable event-intensity $\tilde{\sigma}_{\mathrm{OB}}$ ($\hbar$)	Event relativistic observability $\tilde{\phi}$	*Equivalent* speed [a] $\left|\langle\beta_{\mathrm{R}}\rangle\right|$	'Complete' interactional redshift [b] z
1 [c]	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 equation (6).
[b] See equation (12).
[c] The 'proper' uncertainty principle [i.e., (11)] dictates the minimum $\tilde{\sigma}_{\mathrm{PP}}$, which anchors the entire table.

Following the conservation of linear momentum, equation (6) further predicts $\tilde{\phi} = 1/4$ comes with $\sigma_{\mathrm{OB}} = \hbar/2$, $\left|\langle\beta_{\mathrm{R}}\rangle\right| = \sqrt{3/5}$, and $\langle m_0\rangle = m_{\mathrm{e}}$; $\tilde{\phi} = 3/4$ with $\sigma_{\mathrm{OB}} = 3\hbar/2$, $\left|\langle\beta_{\mathrm{R}}\rangle\right| = \sqrt{1/7}$, and 'effective rest-mass $\langle m_0\rangle$' $= 3m_{\mathrm{e}}$, with the increase due to $\boldsymbol{L}$'s projection magnitude $\hbar$, "embedded" in σ_{OB} . (For brevity, we skip discussions on other combinations of $\boldsymbol{S}$ and $\boldsymbol{L}$.)

If we relax Premise 'c' (in the triple fiducial limit), and if the event is in motion (always *radial* in terms of the event network), equation (6) down-tunes $\tilde{\phi}$ from such exemplified rational numbers dictated only by $\boldsymbol{S}$ and $\boldsymbol{L}$. For instance, consider the e^--e^+ annihilation *event* with $\sigma_{\mathrm{PP}} = 2\hbar$—i.e., the reverse of the event described in the last paragraph—*moving* collinear with the two lab-fixed observers. The relativistic observability $\tilde{\phi}$ via either one of the two resulting photons becomes *smaller* than $\hbar/(2\hbar)$ (see also section 5), where the numerator $|\pm\hbar|$ is the apparent event-intensity in the triple fiducial limit, and the denominator is the invariant σ_{PP} . Upon detection, the photons still reveal $-\hbar$ and $\hbar$ as their (invariant) helicities (relative to the individual photon propagation direction), whose absolute values determine the numerator. Note the law of ROC compromises the photon detection probabilities, *not* the photon intrinsic spin once observed. In this case, the on-axis $\boldsymbol{L}$ for each photon is zero, and the vectorial sum of the two photon spins relative to the lab accounts for $\sigma_{\mathrm{PP}} = 2\hbar$.

In short, the law of ROC is consistent with particle physics in SR. As a partial roadmap, see sections 5, 8.1 and 8.2, for the general meaning of fractional $\tilde{\phi}$ (rational or irrational).

5. Fractional observability

For observation via a *massless* elementary particle, the law of ROC in stochastic SR turns into

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

per (6) and (as a bait) the relativistic Doppler relation [10,11] of $\langle \beta_{\mathrm{R}} \rangle$ and z—where $\langle \beta_{\mathrm{R}} \rangle$ is meaningful only between mass-carrying entities, and z is of the massless elementary particle vectoring from event to observer.

Now that the massless elementary particle may offer the spacetime yardstick to describe the (vectoring) *mass* particle, equation (12) (if generalized in terms of particle-wave duality) holds for observation via any (event-to-observer) particle, *whether* massless or not. That is, z in (12) is valid for a mass particle as well. (Herein z is an abbreviation of $\langle z \rangle$.)

Derivation of (6) and hence (12) does not differentiate the meaning for $\Delta(X)$ between a) $\Delta(X)$ of a fundamental quantum event and b) $\Delta(X)$ of a composite 'event' spanning—at our definitional choice—a contiguous subsection of the event network. Equation (12) applies to observations of composite cosmic events or objects, in the quasi 'universe of stochastic SR' for now (and the universe of GR, after generalization in section 6).

The relativistic 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 specific 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) $\tilde{\phi}$ per (12), and vice versa. (Such disciplined flexibility to define the event also holds in GR, after generalization in section 6.)

For instance, to a *unidirectional* observer (using only one detector), an e^--e^+ annihilation corresponds to detecting *one* of the two resulting photons, and the photon may have partially fulfilled the happening's 'complete' 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 (12); for z' and $\tilde{\phi}'$, the original 'partial' event was the referenced 'complete' event.

We are observers unidirectional to any cosmic event (or object), so we always get to define the counterpart 'stationary event (or object) for study' as if it had $z = 0$ and $\tilde{\phi} = 1$ [in the universe of GR (see below)]. This is a conceptual leap—recall, in the discussion of the "triple limit" (section 4), it takes multiple $\tilde{\phi}$s to sum up to one.

6. True observables

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 observer's local observables that all observers nominally share—and thereby share the law—so 'we' can correlate observers of a common event* $\underline{\mathrm{E}}$ (underscored for distinction from energy E), *via* $\underline{\mathrm{E}}$ *'s intrinsic properties*.

Also as a single event, the generalized 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' $v_i(\underline{\mathrm{E}}, R_{\underline{\mathrm{E}}\mathrm{O}})$ of a) event $\underline{\mathrm{E}}$ that emitted the elementary particle and b) the relativity context (denoted as a quasi variable $R_{\underline{\mathrm{E}}\mathrm{O}}$, for short) connecting $\underline{\mathrm{E}}$ to the observer.

To be eligible as a (global) law, the local relation among the v_i involves no $R_{\underline{\mathrm{E}}\mathrm{O}}$, 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 $R_{\underline{\mathrm{E}}\mathrm{O}}$, and corresponds to an equation explicit of v_i, but 'implicit' of $R_{\underline{\mathrm{E}}\mathrm{O}}$ through $v_i(\underline{\mathrm{E}}, R_{\underline{\mathrm{E}}\mathrm{O}})$.

In notation, the above conception condenses to

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

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

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

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

Because of not explicitly involving $R_{\underline{\mathrm{E}}\mathrm{O}}$, *an equation in the form of (13) that holds in the asymptotic limit of stochastic SR also holds in all other relativistic context* $R_{\underline{\mathrm{E}}\mathrm{O}}$. *Stochastic SR* can therefore serve as a scaffold to help derive physical laws among *true* v_i. Both $\tilde{\phi}$ $\left(\equiv \tilde{\sigma}_{\mathrm{OB}}/\tilde{\sigma}_{\mathrm{PP}}\right)$ and z $\left[\equiv \left(L_{\mathrm{OB}}/L_{\mathrm{PP}}\right) - 1\right]$ act as $v_i(\underline{\mathrm{E}}, R_{\underline{\mathrm{E}}\mathrm{O}})$, for each is a simple ratio with a) the numerator reflecting only $\underline{\mathrm{E}}$ and $R_{\underline{\mathrm{E}}\mathrm{O}}$ and b) the denominator only $\underline{\mathrm{E}}$. 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 $R_{\underline{\mathrm{E}}\mathrm{O}}$). Thereby, equation (12) holds in GR, that is, even *after we obliterate all the scaffolding context of stochastic SR*—such as a) $\tilde{\phi}$'s 'anatomy' in terms of $\Delta(\_)$ [for the observer 'may' be clueless of $\tilde{r}$, $\tilde{p}$, $\tilde{\tau}$, and $\tilde{m}_0$, let alone of the corresponding $\Delta(_)$s] and b) equation (6) [for $\langle \beta_{\mathrm{R}} \rangle$ is a pseudo observable (see appendix I)].

Postulate 3 formally legitimates the use of SR's Doppler effect as a bait, to put (12) in a beyond-SR context (see section 5), in that the (generalized) observer is oblivious to the nature of the redshift in relation to SR, GR, or even quantum gravity.

Considering only GR-based luminosity-distance calibrations, the current cosmological model for supernova observations is not of full-fledged GR. Intrinsic to GR, equation (12) amends the model by rendering 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 (12) is 'neutral' to any cosmological model, whether involving the Big Bang.

7. No cosmic acceleration

Per section 6, the law of ROC [i.e., (12)] is intrinsic to but hidden in GR [in the limit of zero $\Delta(c_{1,\,\mathrm{R}})$]. (See appendix K for a different perspective of the rationale.) As a result, we have interpreted photon fluxes from cosmological objects with GR-based luminosity distances [4], but *not* yet with the GR-intrinsic ROC effect. This is the status quo in "identifying cosmic acceleration" [1–3].

Any 'plain observational fact' comes with a default interpretation or misinterpretation, and a subliminal misinterpretation distorts a 'plain observational fact,' without our awareness. As observers, we are an integral but often neglected part of the cosmological model. Shown below is how cosmic acceleration disappears after corrections per (12) on our part, instead of on the "rest" of the cosmological model.

Being the major "evidence of cosmic acceleration [1–3]," figure 3 illustrates 'observed-magnitude [5] $\underline{m}$ vs. redshift z' of type Ia supernovae. (The underscored $\underline{m}$ is for distinction from mass m.) In the figure, the current paper additionally depicts the ROC-corrected $\underline{m}$ (curve of blue dots) for the critical cosmic expansion (CCE) of 'no' vacuum energy (i.e., zero Ω_Λ):

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

(see appendix L for derivation), where a) $\underline{m}_{\mathrm{CCE}}(No\ ROC;\, z)$ is the CCE curve as if the universe-traversing photons came with no ROC and b) $\tilde{\phi}(z)$ is the same as (12) shows.

Curve $\underline{m}_{\mathrm{CCE}}(ROC;\, z)$ 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, $\underline{m}_{\mathrm{CCE}}(ROC;\, z)$ intersects eight uncertainty bars of all nine data points (red dots) from the High-Z Supernova Search [2]. Denying "cosmic acceleration," the supernovae data coincide with the 'new' CCE curve of zero Ω_Λ, 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.

Moreover, the law of ROC dissolves the crisis, identified by Ref. [18], of missing

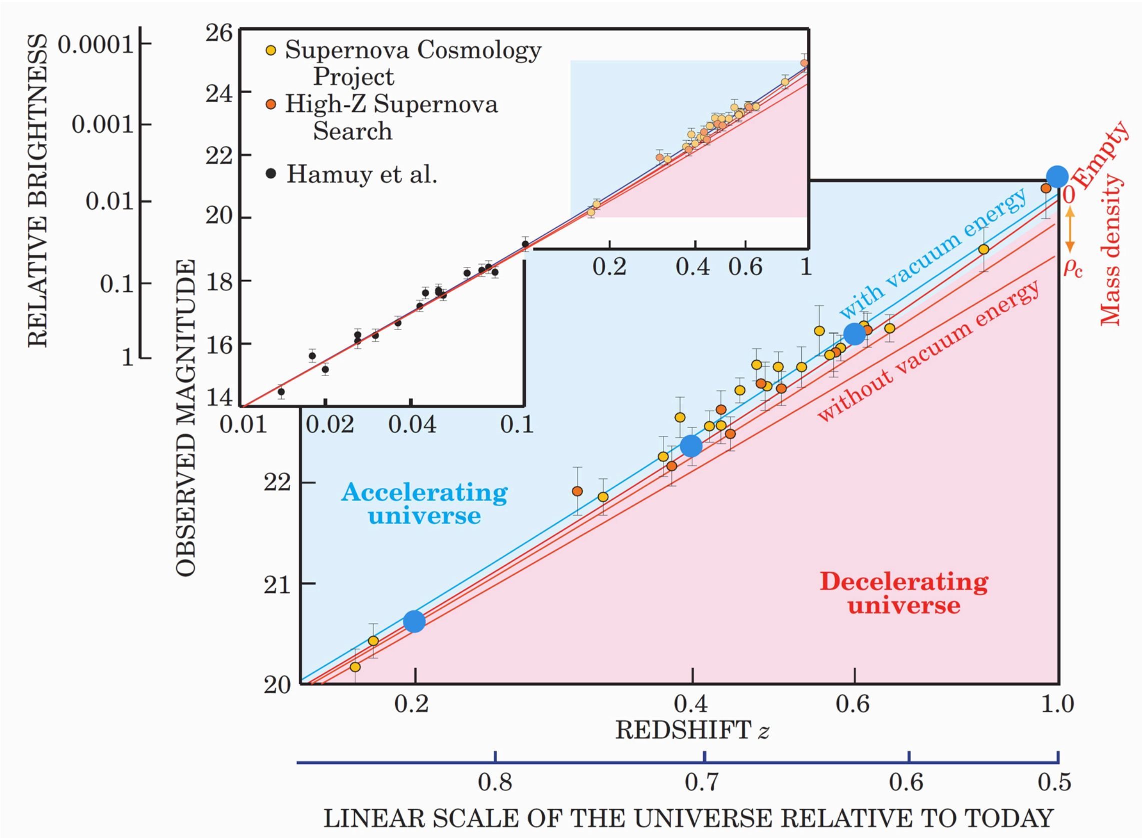

Figure 3. Type Ia supernovae's 'Observed-magnitude [5] $\underline{m}$ **vs. redshift** z**'** ***denies*** **cosmic acceleration.** {Other than the four blue dots, the figure along with the original legend (italicized) below is a reproduction with permission from Ref. [1], Copyright 2003, American Institute of Physics.} 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.*"

Correcting for the *relativistic observability compromise* (ROC), namely, for the relativistic quantum efficiency, equation (15) yields the theoretical observed-magnitude $\underline{m}_{\mathrm{CCE}}(ROC;\, z)$ (curve of blue dots) for the *critical* cosmic expansion (CCE) of no vacuum energy (i.e., zero Ω_Λ). Free of parameter fitting, the effect lifts the "orthodox" zero-Ω_Λ CCE curve (labeled with ρ_c) to $\underline{m}_{\mathrm{CCE}}(ROC;\, z)$, which coincides with the observational data, to within observational uncertainty. The matching implies no discernible cosmic acceleration, or no effect due to dark energy. • The figure predicts: Neglecting the ROC effect further leads to illusory "acceleration *on* cosmic acceleration," as the data interpretation, particularly for $z > 0.7$, remains unamended (see section 8.5).

400% of hydrogen-atom ionizing photons in cosmological observations at z slightly above 2—where $(1-\tilde{\phi})/\tilde{\phi}$, as figure 1 shows, matches the "400%," again free of parameter fitting.

8. Concluding remarks

8.1. Relativistic uncertainty principle

After generalized for the context of GR in section 6, equation (12) [with $1+z$ being $\Gamma\ \left(\equiv L_{\mathrm{OB}}/L_{\mathrm{PP}}\right)$] entails the quantum event's *general-relativistic* observability amplitude (i.e., observation *probability amplitude*)

$$\psi = \mathrm{e}^{\mathrm{i}\delta}\sqrt{\tilde{\phi}} = \mathrm{e}^{\mathrm{i}\delta}\sqrt{\frac{2}{\Gamma^2+\Gamma^{-2}}} = \begin{cases} \mathrm{e}^{\mathrm{i}\delta'}\dfrac{\sqrt{2}}{\Gamma \pm \mathrm{i}\,\Gamma^{-1}} & \text{or} \\ \mathrm{e}^{\mathrm{i}\delta'}\dfrac{\sqrt{2}}{\Gamma^{-1} \pm \mathrm{i}\,\Gamma}, & \end{cases} \tag{16}$$

where $\mathrm{e}^{\mathrm{i}\delta}$ and $\mathrm{e}^{\mathrm{i}\delta'}$ are each a unitary phase factor—whether the event-to-observer elementary particle is massless. Like $\tilde{\phi}$ (see figure 1), amplitude ψ profiles a universal resonance in Γ (or Γ^{-1}), peaking (now in modulus) at $\Gamma = 1$. (An interesting observation is, per (12) or (16) alone, we cannot distinguish between cosmic expansion and cosmic shrinkage.) As a reminder, between observer and event, Γ is the relative scale not only in length but also in momentum, time, and energy.

Equation (16) leads to the *general-relativistic* uncertainty principle [via (G.10), in appendix G]:

$$\tilde{\sigma}_{\mathrm{OB}} \geq \frac{\hbar}{\Gamma^2+\Gamma^{-2}} \left(=\tilde{\phi}\ \frac{\hbar}{2}\right), \tag{17}$$

reflecting the *relativistic event-intensity reduction* in the event network of quantum gravity (see section 2, for the 'preliminary' network), where a) all the scaffolding context of stochastic SR is no longer necessary (see section 6) and b) each observer is flexible in 'its own' defining the event of concern (see sections 6 and again 5).

In SR, inequality (17) may take additional forms:

$$\Delta(r)\Delta(p) \geq \begin{cases} \dfrac{\hbar}{\left(\dfrac{\lambda}{\lambda_0}\right)^2 + \left(\dfrac{\lambda_0}{\lambda}\right)^2} & \text{or, equivalently,} \\ \left(\dfrac{1-\langle\beta_{\mathrm{R}}\rangle^2}{1+\langle\beta_{\mathrm{R}}\rangle^2}\right)\dfrac{\hbar}{2}, & \end{cases} \tag{18}$$

with the former expression showing the wave property of the vectoring particle, and the latter expression [due to (6)] the relative corpuscular property a) between the event (or entity) and the observer or b) between the vectoring particle, if carrying mass, and the observer. [The latter expression in (18) is also derivable from 'classical' SR as a limit in stochastic SR, by setting $c_{\mathrm{R}} = 1$ in appendices A and D.] [See appendix N, to confirm the Lorentz invariance of (18).]

Being a clear-cut visualization, figure 4 verifies (18). The Heisenberg uncertainty principle is *nonrelativistic* (see appendix M), namely, of the limit with $\langle \beta_{\mathrm{R}} \rangle \equiv \beta = 0$, or with $\Gamma = \lambda / \lambda_0 = 1$. The misbelief of the Heisenberg version being relativistic has diverted our eyes from figure 4 for nearly a century.

Equation (17) diminishes the observer-effective vacuum energy and thereby drastically mitigates the cosmological constant problem [20] in that the (massive) Planck particles (in default radial-only observations) are at the speed of light and thus literally unobservable.

Inequalities (11) and (17) are principles of both uncertainty and event-intensity. It is the latter interpretation that leads to the name ROC.

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 (particle-wave–emitting) event. Accepting "cosmic acceleration,"—namely, denying relativistic event-intensity reduction or the law of ROC—connotes 100% statistical observability of an event emitting a wave with λ '$=$' 0 or ∞, that is, emitting an oxymoronic "wave of *no* wave!" It is unsurprising that the law of ROC dissolves several cosmic enigmas (three in section 7 already), all free of parameterization.

Further holding in the e^{-}-e^{+} interaction, equation (16) [and (17), i.e., the relativistic uncertainty principle] partly hints on how to better understand integrability issues of quantum field theory. For instance, the current prevailing concept of 'spin network' appears incomplete, for neglecting (16).

8.2. Theoretical hierarchy

Part of the cornerstone of current relativistic QM is SR, signified by the spacetime-interval equation with its phase-space conjugate (i.e., the Klein-Gordon relation). (Recall derivation [21] of the Dirac equation embarks with the latter.) Amending SR into stochastic SR relates event with observer—for a theory is operationally unphysical if a) involving no observer or b) offering no template for experimental data logging. (Review section 3, in case the rationales still sound either surprising or "too trivial.").

Associating $\sqrt{c_{\mathrm{R}}}$ with each existing fundamental dynamic variable in our amending SR reflects the law of ROC could have emerged—though *not* in the fullest form (see Appendix K)—in current SR and thus in current relativistic QM. So the law of ROC looks odd, only at first glance. Corresponding modifications to any field equation are straightforward; presenting them in here may seem pedantic.

SR is a *necessary* condition or premise of any specific filed equations. It is backward in hierarchy to request or create a "brand new" field equation as the starting point to derive the (more fundamental) law of ROC.

To dissolve cosmological enigmas, the law of ROC propagates from stochastic SR into relativistic QM and then, skipping quantum gravity, into GR. As a precise pivotal connection, the wavelength ratio λ / λ_0 —in relativistic QM and then—in GR *equals* the length-scale ratio $L_{\mathrm{OB}} / L_{\mathrm{PP}}$ in GR. Thereby, the law of ROC is precise (and hidden) in GR. Current mainstream cosmology need not modify GR but need amend the current

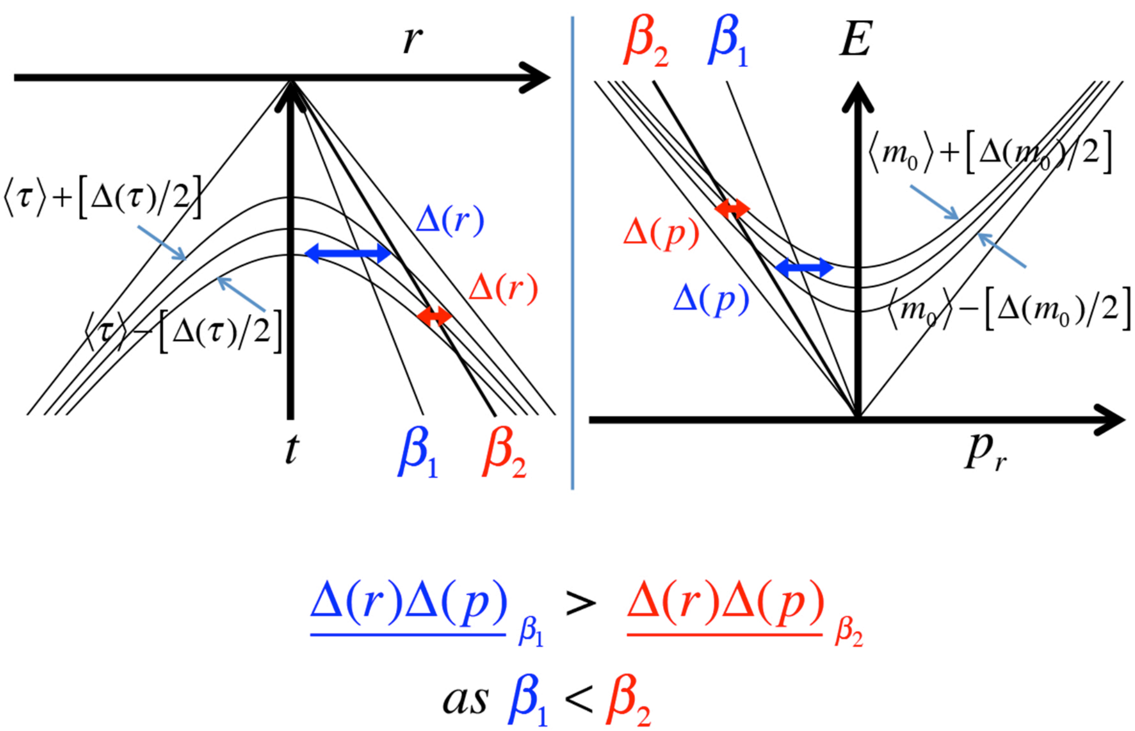

Figure 4. 'Classical' special relativity (SR) hints the Heisenberg uncertainty principle needs refinement: Relativistic reduction in *event-intensity* $\Delta(r)\Delta(p)$ **.** This figure has slipped through the crack since Heisenberg in 1927. A mass entity possesses its Lorentz-invariant $\langle\tau\rangle$, $\Delta(\tau)$, $\langle m_0\rangle$, and $\Delta(m_0)$. Within the past light-cone (upper left), an observed entity locates at the intersection of a) the contour (a hyperbolic branch) of $\langle\tau\rangle$ and b) the contour (an origin-passing straight line) of β, where β is the entity's (unitless unsigned) 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, as 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 diagram (upper right), the entity likewise progresses with *ever-decreasing* $\Delta(E)$ and $\Delta(p)$. [In the E-p diagram, the unsigned slope of the straight line labeled with β_i (i = 1 and 2) is β_i^{-1}, and β_i is the hyperbola's unsigned slope at its intersection with the straight line.] • Per both diagrams, $\Delta(r)\Delta(p)$ diminishes, as β [corresponding to $\langle\beta_R\rangle$ in (18)] deviates from 0. So the lower-bound of $\Delta(r)\Delta(p)$ peaks (with "Heisenberg's $\hbar/2$") at $\beta=0$. (Note: The figure is only a hint, as it reflects unphysical limitations imposed by 'classical' SR, which, for instance, forbids uncertainty of the spacetime origin location.)

incomplete GR-based cosmological model, which considers only luminosity distance corrections.

Most crucial is, before maturing quantum gravity, we fished out the law of ROC as its manifestation.

Barely have we observed events per se at relativistic speeds on Earth; barely have we considered 'relativistic events,' let alone their observations, in theory. Our intuition, if any at all, against the law of ROC may have resulted from undue extrapolation from 'nonrelativistic events.' It is prudent to lab-test the law further. It is "further," as the law has so far impeccably realized Occam's razor. Otherwise, further theories would be journeys in philosophy only.

8.3. Lab testability

As a rarity in cosmology, the law of ROC (i.e., figure 1) is *lab*-testable. We a) generate an electron beam—tunable up to 0.9 in speed (1.2 Mev in energy) or faster—to annihilate positrons steady in number density and 'stationary' to the lab (e.g., in an electromagnetic trap), and b) observe, at a grazing angle to the collision axis, how the resulting photon intensity varies with the annihilation *event's* speed β (i.e., half the incident electrons' speed). The law of ROC predicts the effective efficiency for the photon detection to be $\tilde{\phi}(\beta)\ \zeta_{\mathrm{D}}\left[\lambda(\lambda_0,\ \beta)\right]$, where $\zeta_{\mathrm{D}}(\lambda)$ is the detector's quantum efficiency. The intensity measurements at the grazing angle are preferably in opposing directions, one for blueshift, and the other redshift. This experiment checks figure 1 with event speeds below 0.5 to the lab.

To check for speeds *above* 0.5 as well, we can employ an e^--e^+ collider a) tunable in each beam-speed up to 0.9 or faster and b) reversible in direction for one of the two (nearly coaxial) beams, to create relativistic *catch-up* collisions. Unlike dark energy, the proposed lab-tests are within our direct reach.

From such relativistic experiments, if conducted in the EPR (for 'Einstein, Podolsky, and Rosen') correlation manner [22], the law of ROC may hopefully ease the tension between non-relativistic quantum information theory and non-quantum relativity theory [23]. The current quantum information theory is yet to become relativistic.

8.4. Illusory 'asymmetric quasars'

A further verification of the law of ROC is to account for the enigma raised by Ref. [19]: Why has it been easier to see gas jets *relativistically* blowing toward than away *from us*, at *all* high-z quasars? (In most cases, the quasar disks do not embed our line of sight; the enigma is not about obscuration.) We cannot be the "attraction" center of all quasar gas jets in the entire universe, which implies an egregious mistake in the current cosmological model, that is, in our understanding of relativity theory.

Per figure 1, a strong candidate answer lies in the decreasing monotonicity of $\tilde{\phi}(z)$, over $z:(0,\ \infty)$. Namely, blowing toward us recovers part of the compromised observability; blowing away further compromises the already compromised. [As a trivial scenario, if the gas-jet's redshift relative to the quasar equals the quasar's redshift z_{Q} relative to us, then a) the jet blowing toward us shows no redshift to us and b) the jet blowing away from us manifests a redshift of $z_{\mathrm{Q}}(z_{\mathrm{Q}}+2)$.] The law of ROC may cause a drastic contrast between the two. Using (12) to correct the observational imbalance is a recommendation for those who possess the observational database.

8.5. Illusory 'acceleration on acceleration'

Neglecting the law of ROC would further lead to illusions of "acceleration *on* cosmic acceleration," as perceived of in the current mainstream cosmology. Below is how to visualize this unique prediction.

Again, the acronym CCE is short for 'critical cosmic expansion.' As reflected by figure 3, the ROC-adjusted CCE curve (indicated by blue dots) crosses over, at $z \sim 0.7$, the ROC-free cosmic-acceleration curve (thin blue line)—which corresponds to "*a mass density of about* $\rho_{\mathrm{c}}/3$ *plus a vacuum energy density twice that large*" (per S. Perlmutter [1]) in the current cosmology model, where ρ_{c} is the critical density. From z ~0.7 and up, the two curves diverge. Thus, the ROC-adjusted CCE curve traverses a continuum set of ROC-free 'cosmic-acceleration curves with increasing vacuum energy' (starting from $\sim 2\rho_{\mathrm{c}}/3$), which deceives us to believe an acceleration *on* cosmic acceleration.

As a result, it is critical whether type Ia supernovae continue to track the ROC-adjusted CCE curve (to the right of figure 3). If they do, it would be unsurprising to see people unaware of the ROC effect continue to interpret the trend as evidence of "acceleration on cosmic acceleration" or "ever-increasing vacuum energy density over time." As a caveat, the latter would challenge vacuum energy as "dark energy," in that the vacuum energy per unit volume of space should be constant.

In this odd sense, the law of ROC may better preserve vacuum energy as a candidate for "dark energy;" though the law of ROC has so far denied any discernible effect of "dark energy," to within observational uncertainty.

As a reminder, beyond illusory cosmic acceleration, "acceleration *on* cosmic acceleration" was a prediction from 2010, not a retrodiction, and this additional illusion emerged to astronomers in 2016 [24]. We look forward to more observational data from beyond $z = 1$.

8.6. Illusory schizophrenic Hubble constant

As of 2017, the Hubble constant H_0 remains schizophrenic: $67.6^{+0.7}_{-0.6}$ km/s/Mpc ($\equiv H_{0,\,\mathrm{SDSS}}$) from the SDSS-III Baryon Oscillation Spectroscopic Survey [25] but $71.9^{+2.4}_{-3.0}$ km/s/Mpc ($\equiv H_{0,\,\mathrm{HST}}$) from the Hubble Space Telescope [26], with no overlap between their uncertainty bars. To help determine if the conundrum implies a cosmological crisis, we propose to correct $H_{0,\,\mathrm{HST}}$ [per (12) and (15)], but leave $H_{0,\,\mathrm{SDSS}}$ intact, *both* according to the law of ROC—and we expect the correction lowers $H_{0,\,\mathrm{HST}}$. This is a task for those who possess the latest observational data.

Below is a footnote on why no ROC correction to $H_{0,\,\mathrm{SDSS}}$. In Big Bang cosmology, it is common but misleading description that the CMB radiation (detected by the SDSS, for instance) comes from the *distant* "last-scattering surface of plasma deionization," at $z \sim 1100$. In context, this high z differs from that of a supernova. Per the cosmological principle [11], the CMB is independent of spatial location, at an arbitrary but specific cosmic time; it is the *local* remnant radiation resulting from the era remote in time—*not* radiation traveling from the "surface" now remote in space. So the detected CMB and the detector collocate in spacetime, without relative motion. The picture agrees with the CMB being a blackbody radiation—which in theory involves standing waves, not traveling waves. So CMB-based cosmological observations require no ROC correction. If corrected, the predicted CMB would literally vanish. On the other hand, the observability of the CMB serves as an evidence of the ROC effect.

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Appendix A: Stochastic special relativity

This appendix helps section 3 justify replacing 'classical' special relativity (SR):

$$t^2 - r^2 = \tau^2, \tag{A.1}$$

$$E^2 - p^2 = {m_0}^2, \tag{A.2}$$

with stochastic SR:

$$\left(\sqrt{c_\mathrm{R}}\ t\right)^2 - \left(\frac{r}{\sqrt{c_\mathrm{R}}}\right)^2 = \left(\sqrt{c_\mathrm{R}}\ \tau\right)^2 \tag{A.3}$$

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

$$\left(\frac{E}{\sqrt{c_\mathrm{R}}}\right)^2 - \left(\sqrt{c_\mathrm{R}}\ p\right)^2 = \left(\frac{m_0}{\sqrt{c_\mathrm{R}}}\right)^2 \tag{A.4}$$

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

Here begins the derivation. Postulate 2, with the two premises listed below it, demands 'softening' (A.1) and (A.2) as

$$\left({c_\mathrm{R}}^a\ t\right)^2 - \left(\frac{r}{{c_\mathrm{R}}^{1-a}}\right)^2 = \left({c_\mathrm{R}}^a\ \tau\right)^2 \tag{A.5}$$

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

$$\left(\frac{E}{{c_\mathrm{R}}^a}\right)^2 - \left({c_\mathrm{R}}^{1-a}\ p\right)^2 = \left(\frac{m_0}{{c_\mathrm{R}}^a}\right)^2 \tag{A.6}$$

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

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

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

$$\Delta(\tilde{\tau}^2) = 2\left|\langle\tilde{\tau}\rangle\right|\Delta(\tilde{\tau}). \tag{A.7}$$

Owing to the statistical covariance between $\tilde{t} - \tilde{r}$ and $\tilde{t} + \tilde{r}$ being zero, equation (A.5) leads to

$$\Delta(\tilde{\tau}^2) = \sqrt{\left(\langle\tilde{t}\rangle + \langle\tilde{r}\rangle\right)^2 \left[\Delta\left(\tilde{t} - \tilde{r}\right)\right]^2 + \left(\langle\tilde{t}\rangle - \langle\tilde{r}\rangle\right)^2 \left[\Delta\left(\tilde{t} + \tilde{r}\right)\right]^2}\,, \tag{A.8}$$

which, along with (A.7), becomes

$$\Delta(\tilde{\tau}) = \sqrt{\frac{\left[\Delta(\tilde{t})\right]^2 + \left[\Delta(\tilde{r})\right]^2}{2}}\ \sqrt{\frac{1+\langle\beta_{\mathrm{R}}\rangle^2}{1-\langle\beta_{\mathrm{R}}\rangle^2}}, \tag{A.9}$$

with $\langle\beta_{\mathrm{R}}\rangle^2$ substituting for $\left|\langle\tilde{r}\rangle/\langle\tilde{t}\rangle\right|^2$ $\left(=\left|\langle r\rangle/\langle t\rangle\right|^2 \langle c_{\mathrm{R}}\rangle^{-2}\right)$. (Recall r and t are each a differential increment in spacetime, by definition.) In (A.9), $\langle\beta_{\mathrm{R}}\rangle$ must be an *expectation* value—of the event's incidental velocity β_{R} (to the observer) as normalized relative to $\langle c_{\mathrm{R}}\rangle$—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). $\langle\beta_{\mathrm{R}}\rangle$ 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 random variable.)

"Restarting" from $\tilde{\tau} = -(\tilde{t}^2 - \tilde{r}^2)^{1/2}$ [seemingly redundant to (A.5)] gives

$$\Delta(\tilde{\tau}) = \sqrt{\left[\Delta(\tilde{t})\right]^2 + \langle\beta_{\mathrm{R}}\rangle^2 \left[\Delta(\tilde{r})\right]^2}\ \sqrt{\frac{1}{1-\langle\beta_{\mathrm{R}}\rangle^2}}. \tag{A.10}$$

Equating the right-hand sides of (A.9) and (A.10) indicates

$$\Delta(\tilde{t}) = \Delta(\tilde{r})\,, \tag{A.11}$$

regardless of $\langle\beta_{\mathrm{R}}\rangle$ and $\Delta(\tilde{\tau})$. (Note the subtlety of the "redundancy.") The mathematical analogy between (A.5) and (A.6) legitimates substituting $\langle\beta_{\mathrm{R}}\rangle^2$ for $\left|\langle\tilde{p}\rangle/\langle\tilde{E}\rangle\right|^2$ $\left(=\left|\langle p\rangle/\langle E\rangle\right|^2 \langle c_{\mathrm{R}}\rangle^2\right)$ as well and entails

$$\Delta(\tilde{E}) = \Delta(\tilde{p}), \tag{A.12}$$

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

By definition, equation (A.11) is

$$\Delta\left(c_{\mathrm{R}}{}^{a}\ t\right) = \Delta\left(\frac{r}{c_{\mathrm{R}}{}^{1-a}}\right), \tag{A.13}$$

which expands into

$$\left[\Delta(t)\right]^2 + \left[a^2\langle\tau\rangle^2 + (2a-1)^2\langle r\rangle^2\right]\left[\Delta(c_{1,\mathrm{R}})\right]^2 = \left[\Delta(r)\right]^2, \tag{A.14}$$

with $\Delta(c_{1,\mathrm{R}})$ being the ratio of $\Delta(c_{\mathrm{R}})/\langle c_{\mathrm{R}}\rangle$. Per (A.14) and the measurement principle of $\Delta(\_) > 0$, parameter a—in (A.5) and (A.6)—must be $1/2$ in that $\Delta(r)$ is *independent* of $\langle r\rangle$ in statistics. So we arrive at (A.3) and (A.4).

Appendix B: Hermitian time and energy

Premise 1 per Pauli [27], a Hermitian (self-adjoint) time operator conjugate to a Hamiltonian would require both manifest a continuous unbounded spectrum of $(-\infty, \infty)$. Thereby, Pauli's theorem [27] indoctrinates "time correspond to no Hermitian operator"

—in that, "as default truth," energy is either bounded or discrete. Being a faith or myth, the theorem has since prevailed in physics teaching. However, is the "default" true?

Pauli's enshrined but counterintuitive theorem has motivated mathematical endeavors to enact time to become Hermitian. Two recent examples are references [28] and [29]. Reviewing such efforts is beyond the current paper. Instead, we focus on bypassing Pauli's theorem, by amending the context that "energy is bounded or discrete." To do so, we clarify two concepts, one for inside individual coherent entities (i.e., event-nodes of the event network) and one outside (i.e., the event network 'among' event-nodes).

In any physical measure, a physical entity must be finite nonzero. As a result, energy is bounded (from above and below) *within* a coherent entity, *before* collapsed on observation. Coherence connotes 'intact,' which means yet missing in the observer's operational perspective (e.g., in a conscious observer's spacetime and momentum-energy phase-space). The time and energy internal to a coherent entity must disengage from the external counterparts. If in the original context, Pauli's theorem is an overgeneralization from inside coherent entities to outside, but only the latter belongs to the conscious observer's perspective.

In the conscious observer's perspective, the Klein-Gordon relation ($E^2 - P^2 = {m_0}^2$) imposes a lower bound m_0 to E (in the positive-m_0 cone); likewise, the spacetime-interval equation ($t^2 - r^2 = \tau^2$) imposes an upper bound τ to t (in the past light-cone). The two equations restrict a) the 'external' behavior of the coherent entity (in the observer's perspective), *not* b) the observer's perspective per se. So to speak, they do *not* constrain the observer-owned E- and t-scale.

Note the conscious-observer view connotes a limiting scenario of 'nearly' (but not exactly) intact coherent entities, which otherwise would disappear from the (observer's) spacetime.

On the other hand, it requires a continuous E interval to at least locally encompass *any* and all (positive) m_0 of concern. In addition, with respect to any m_0, the encompassing interval of E *may* locally (in a mathematical sense) behave as if globally spanning (–∞, ∞), though extending into the fictitious negative-m_0 cone. [Similarly, to any τ, the encompassing interval of t may locally behave as if globally spanning (–∞, ∞), extending into the yet intangible future light-cone.] Not in physics, such intervals of (–∞, ∞) are significant in mathematics—which is critical in that Pauli's theorem is a mathematical concern. Thereby, premise 1 (see above) helps legitimate that energy and time are Hermitian and conjugate to each other—in the conscious observer's perspective, and generally in the *event network*. External to the coherent entity of concern means freedom in mathematics. Thereby, we a) remove "Pauli's theorem (concern)" and QM's stipulation that time be an externally provided parameter and b) corroborate

$$\left[\hat{x}_\mu, \hat{p}_\nu\right] = \mathrm{i}\,\hbar\hat{\xi}_{\mu\nu}\ , [21] \tag{B.1}$$

with $\hat{\xi}_{\mu\nu}$ being the metric tensor, is characteristic of the manifold's *tangent* bundle in relativistic QM. The view agrees with the fundamental premise that physics need be 'tangent or local' to coherent entities of concern. All the nonlocal part of the perspective is now a removable scaffold.

To be more explicit, a *true* Hamiltonian reflects both event and observer. A simple way to convert a pseudo Hamiltonian (e.g., of a "textbook" atom) is to add a seemingly inconsequential *energy offset* that can range $(-\infty, \infty)$, to signify the observer's arbitrary but specific view. The resulting Hamiltonian approximates a 'nearly' intact system—in terms of observational perturbation. For being not exactly intact, the Hamiltonian exists in the conscious observer's operational perspective. The trivial conversion also justifies why the literature accepts pseudo Hamiltonians.

In a subliminal manner, the literature *has* dethroned Pauli's theorem, as long since evidenced by (B.1).

Appendix C: $\langle \tau \rangle$ and $\langle m_0 \rangle$'s operational definition

With $a = 1/2$, equation (A.14) reduces to

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

which, via the analogy between (A.3) and (A.4), implies

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

Equation (C.1) manifests a mutual constraint between a) $\langle \tau \rangle$ intrinsic to the event and b) the $\Delta(_)$s which are characteristic of the event-observer pair; likewise, equation (C.2) between $\langle m_0 \rangle$ and its corresponding $\Delta(_)$s. As a caveat, owing to such mutual constraints, these $\Delta(_)$s cannot take arbitrary values among them (as the symbol of $\Delta(\_)$ could have connoted in the usual sense). It is under such mutual constraints that equation (C.1) serves as an operational definition of $\langle \tau \rangle$, and equation (C.2) as an operational definition of $\langle m_0 \rangle$. (The definitions are operational for being based on operational $\Delta(_)$s.)

One can verify the interplay consistency among the three $\Delta(_)$s in (C.1) on a *classical*-SR spacetime diagram, which reflects $\Delta(c_{1,\mathrm{R}})$ by 'backward' referencing the precise light cone to the fuzzy event 'confined' with $\Delta(t)$, $\Delta(r)$, and invariant $\Delta(\tau)$.

$\langle \tau \rangle$ and $\langle m_0 \rangle$ must be a) positive for any physical *event* and b) nonnegative for any elementary *particle*. Equations (C.1) and (C.2) hold not only in the event observation but also in describing an observed particle. All the fundamental $\Delta(_)$s being nonzero still permits proper-timeless and rest-massless elementary particles.

Division by zero is indeterminate. It is (nonzero) $\Delta(c_{1,R})$ in (C.1) and (C.2) that "turns on" the event and elementary particle's proper-time and rest-mass. Zero $\Delta(c_{1,\mathrm{R}})$ is an intrinsic flaw in 'classical' SR. *To be physical, SR should refer to stochastic SR, not 'classical' SR.*

Appendix D: Observability in stochastic SR

Equation (A.11) converges (A.9) and (A.10) to the same form(s):

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

Likewise, equation (A.12) results in

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

Involving no QM, the derivations of (D.1) and (D.2) depend only on a) the definition of standard deviation $\Delta(\_)$ and b) stochastic SR. At the quantum-event level, $\Delta(\_)$ must correspond to the uncertainty. Equations (D.1) and (D.2) are therefore essential in quantum observation, so is their multiplicative combination, which gives

$$\tilde{\phi} = \frac{1-\langle\beta_{\mathrm{R}}\rangle^2}{1+\langle\beta_{\mathrm{R}}\rangle^2}, \tag{D.3}$$

or, equivalently,

$$\left(1+\langle\beta_{\mathrm{R}}\rangle^2\right)\left(1+\tilde{\phi}\right) = 2 \ , \tag{D.4}$$

where

$$\tilde{\phi} \equiv \frac{\tilde{\sigma}_{\mathrm{OB}}\ \left[\equiv \Delta(\tilde{r})\Delta(\tilde{p})\right]}{\tilde{\sigma}_{\mathrm{PP}}\ \left[\equiv \Delta(\tilde{\tau})\Delta(\tilde{m}_0)\right]} \tag{D.5a}$$

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

with each constituent

$$\Delta(\tilde{X}) = \sqrt{\left[\Delta(X)\right]^2 + \frac{1}{4}\langle X\rangle^2\left[\Delta(c_{1,\mathrm{R}})\right]^2} \ , \tag{D.6}$$

in (D.5a) and (D.5b). So $\langle X\rangle\Delta(c_{1,\mathrm{R}})\ (\neq 0)$ increases the event-intensity.

In the limit of zero $\Delta(c_{1,\mathrm{R}})$, $\tilde{\phi}$ becomes $\bar{\phi} \equiv \Delta(r)\Delta(p)\ \left[\Delta(\tau)\Delta(m_0)\right]^{-1}$ or, equivalently, $\Delta(t)\Delta(E)\ \left[\Delta(\tau)\Delta(m_0)\right]^{-1}$, where the two *nonzero* numerators highlight 'classical' (nonstochastic) SR's self-contradiction between a) nonzero event *volumes* [i.e., $\Delta(t)\Delta(r)$; not event-intensities] in spacetime enforced by the uncertainty principles and b) *zero* event volumes enforced by the a priori constant speed of light.

Appendix E: No stationarity

Equation (D.4) leads to

$$\left|\langle\beta_{\mathrm{R}}\rangle\right|\Delta\left(\langle\beta_{\mathrm{R}}\rangle\right)=\frac{\Delta(\tilde{\phi})}{\left(1+\langle\tilde{\phi}\rangle\right)^{2}}, \tag{E.1}$$

which prohibits $\langle\beta_{\mathrm{R}}\rangle$ 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 $\langle\beta_{\mathrm{R}}\rangle=0$ leaves intact the prediction of $\lim_{\left|\langle\beta_{\mathrm{R}}\rangle\right|\to 0^{+}}\tilde{\phi}=1,$ per (6) or (D.4).

Appendix F: 'Discovery' of Higgs boson

By definition, an elementary particle is 'structureless' or noncomposite. The LHC's announcement [9] of discovering the elementary (spin-0) Higgs boson [30] fell short of verification in this regard. Were it structureless, Wigner's seminal analysis of the Lorentz group [16]—which forbids spin-zero elementary particles—would be incorrect or challenged [17], so would special relativity (SR), of which the Lorentz group is characteristic. It is improper to celebrate the "discovery" with SR, or without denying Wigner's Nobel-awarded publications. Did we mistake a meson (i.e., a quark-antiquark pair) for the "Higgs boson," rhyming the history, of the 1940s, we mistook pions for the *elementary* mediators between protons?

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

For the Pauli vector $\vec{\eta}$ in the isotropic 3D space, the Pauli matrices [21,31]

$$\hat{\eta}_{\mathrm{x}}\equiv\begin{pmatrix}0 & 1\\ 1 & 0\end{pmatrix},\ \hat{\eta}_{\mathrm{y}}\equiv\begin{pmatrix}0 & -\mathrm{i}\\ \mathrm{i} & 0\end{pmatrix},\ \text{and}\ \hat{\eta}_{\mathrm{z}}\equiv\begin{pmatrix}1 & 0\\ 0 & -1\end{pmatrix},$$

form a basis set. From applying $\hat{\eta}_{\mathrm{y}}$ and $\hat{\eta}_{\mathrm{z}}$ to two independent self-adjoint operators $\hat{A}$ and $\hat{B}$ of same dimension, two degree-2 algebraic operators result as follows:

$$\begin{pmatrix}\hat{A} & \hat{B}\end{pmatrix}\hat{\eta}_{\mathrm{y}}\begin{pmatrix}\hat{A}\\ \hat{B}\end{pmatrix}=\mathrm{i}\left[\hat{B},\,\hat{A}\right], \tag{G.1}$$

$$\begin{pmatrix}\hat{A} & \hat{B}\end{pmatrix}\hat{\eta}_{\mathrm{z}}\begin{pmatrix}\hat{A}\\ \hat{B}\end{pmatrix}=\hat{A}^{2}-\hat{B}^{2}. \tag{G.2}$$

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

Suppose $F(\_)$ is a function, and we have identified a corresponding *physical* equation $F(\hat{\eta}_{\mathrm{d'}})\ \left[\equiv F(\vec{\eta}\cdot\vec{r}_{1,\,\mathrm{d'}})\right]=0$, for a specific direction d' (in the 3D space), in which $\vec{r}_{1,\,\mathrm{d'}}$ is the unit vector. Then, being a presumption same as in Pauli's theory for electron spin [21,31],

$$F(\hat{\eta}_{\mathrm{d}})\ \left[\equiv F(\vec{\eta}\cdot\vec{r}_{1,\,\mathrm{d}})\right]=0 \tag{G.3}$$

holds true for *all* directions d—agreeing with a physical equation is invariant under 3D rotation.

In stochastic SR of 1D (which is characteristic of the event-observer pair), we have the following equations of operators for QM:

$$\hat{\tilde{t}}^2 - \hat{\tilde{r}}^2 = \hat{\tilde{\tau}}^2 , \tag{G.4}$$

$$\hat{\tilde{E}}^2 - \hat{\tilde{p}}^2 = \hat{\tilde{m}}_0{}^2 . \tag{G.5}$$

(When without the hat ^, each symbol may refer to the observed value of the corresponding observable.) See appendix B, for why time still corresponds to a self-adjoint operator in relativity.

Per (G.1)–(G.3), differencing (G.4) and (G.5),

$$\left(\hat{\tilde{E}}^2 - \hat{\tilde{t}}^2\right) - \left(\hat{\tilde{p}}^2 - \hat{\tilde{r}}^2\right) = \hat{\tilde{m}}_0{}^2 - \hat{\tilde{\tau}}^2 , \tag{G.6}$$

implies

$$\left[\hat{t},\, \hat{E}\right] - \left[\hat{r},\, \hat{p}\right] = (\equiv)\left[\hat{\tau},\, \hat{m}_0\right]. \tag{G.7}$$

Notice tildes may disappear in (G.7), by the definitions of the tilded observables [see (A.3) and (A.4)]. In addition, per (B.1) [21],

$$\left[\hat{r},\, \hat{p}\right] = -\left[\hat{t},\, \hat{E}\right] \tag{G.8a}$$

$$= +\mathrm{i}\hbar\hat{I} , \tag{G.8b}$$

where the plus sign is of the prevailing convention in the literature. Equations (G.7)–(G.8b) hence yield the "double-sized" commutator:

$$\left[\hat{\tau},\, \hat{m}_0\right] = -2\mathrm{i}\hbar\hat{I} . \tag{G.9}$$

For an arbitrary but specific normalized quantum state W, the Robertson uncertainty relation is valid between two conjugate observables $\hat{A}$ and $\hat{B}$ [32]:

$$\Delta(A)\Delta(B) \geq \frac{1}{2}\left|\left\langle\left[\hat{A},\, \hat{B}\right]\right\rangle_{\mathrm{W}}\right|. \tag{G.10}$$

(See appendix M for the meaning of state normalization. In here, it is in the usual sense.) Combining (G.9) and (G.10) gives the 'proper' uncertainty principle:

$$\left(\tilde{\sigma}_{\mathrm{PP}} >\right)\ \Delta(\tau)\Delta(m_0)\ \left(\equiv \sigma_{\mathrm{PP}}\right)\ \geq \hbar \tag{G.11}$$

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

The larger greatest-lower-bound for (G.11) agrees with the light-cone pinching the wavefunction at the origin (namely, the 'proper' location)—in both the spacetime diagram and the phase-space diagram—and thus further spreading the wavefunction in time and energy.

Appendix H: Electron-positron energy gap

The energy gap between electron e^- and positron e^+ is twice the electron rest-mass m_e [28]. In the mildest e^--e^+ pair-production event, e^- 'sees' e^+ higher by $2m_\mathrm{e}$ in energy, and vice versa, per charge conjugation.

Below we check (6)'s [or (D.4)'s] validity against this requirement, in the limit of a) $\Delta(c_{1,\mathrm{R}})$ vanishes and b) each elementary particle has quasi 'completed' its interactional redshift 'in' its emission event. Because e$^-$ 'carries' $\bar{\phi} = 1/2$ from the mildest e$^-$-e$^+$ pair-production event, equation (6) predicts the *equivalent* (*pseudo*) relative speed $|\langle \beta_\mathrm{R} \rangle|$ 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 $m_\mathrm{e}\left(1-\langle \beta_{+-} \rangle^2\right)^{-1/2}$, so the minimum E_{+-}, namely, the e$^-$-e$^+$ energy gap, turns out $2m_\mathrm{e}$.

Both $\langle \beta_\mathrm{R} \rangle$ and $\langle \beta_{+-} \rangle$ in here are nominal parameters—instead of velocities in SR. The justification of the above calculation lies in, first, equation (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, second, equation (12) is equivalent to (6) in stochastic SR.

Appendix I: $\langle \beta_\mathrm{R} \rangle$ as pseudo observable

Outside SR, $\langle \beta_\mathrm{R} \rangle$ is meaningless. As an "observable," $\langle \beta_\mathrm{R} \rangle$ 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 $\langle \beta_\mathrm{R} \rangle$). For being nonlocal to the observer, $\langle \beta_\mathrm{R} \rangle$ is not 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 $\langle \beta_\mathrm{R} \rangle$, neither (nominal) stationarity nor the statistical speed of light is a property intrinsic and specific to the event.

Appendix J: No observability at dawn of time

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

$$1+z = \frac{a(t_{\mathrm{C}0})}{a(t_\mathrm{C})}, \tag{J.1}$$

where z is the cosmological redshift, $a(t_\mathrm{C})$ the Friedmann scale factor of *then* (at cosmic-time t_C), and $a(t_{\mathrm{C}0})$ that of *now* (at cosmic-time $t_{\mathrm{C}0}$). Along with (J.1) and $a(t_{\mathrm{C}0}) = 1$, equation (12) turns into

$$\tilde{\phi}(t_\mathrm{C}) = \frac{2}{a(t_\mathrm{C})^2 + a(t_\mathrm{C})^{-2}}, \tag{J.2}$$

showing how the observability of the cosmic history has been fading away over the cosmic-time and approaching zero, as t_C [and $a(t_\mathrm{C})$] backward-approaching zero. Equation (J.2) indicates 0^+ observability expected of the extreme onset of the Big Bang, agreeing nothing 'before' the onset is observable.

Appendix K: ROC in GR

Per (D.4)–(D.6),

$$\left(1+\langle\beta_{\mathrm{R}}\rangle^{2}\right)\left(1+\overline{\phi}\right)=2 \tag{K.1}$$

holds in the limit of zero $\Delta(c_{\mathrm{R}})$. Notice (K.1) 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 (12), to GR, because 'classical' SR anchors GR, *within* the limit [of zero $\Delta(c_{\mathrm{R}})$] per se.

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

Appendix L: Correction on star magnitude

In astronomy, a cosmic object's observed-magnitude $\underline{m}$ relates to its absolute magnitude $\underline{M}$ [5] by

$$\underline{m}=\underline{M}+2.5\log_{10}\left(\frac{F_{\underline{M}}}{F}\right), \tag{L.1}$$

where F is the observed photon 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* [4]—*but the inherent ROC effect yet to be corrected for—per GR*, which constitutes the *"orthodox interpretation"* for supernova observations.

To include the ROC effect, equation (L.1) becomes

$$\underline{m}=\underline{M}+2.5\log_{10}\left(\frac{F_{\underline{M}\times}\ \tilde{\phi}(z_{10\text{ pc}})}{F_{\times}\ \tilde{\phi}(z)}\right) \tag{L.2a}$$

$$\cong\underline{M}_{\times}+2.5\log_{10}\left(\frac{F_{\underline{M}\times}}{F_{\times}\ \tilde{\phi}(z)}\right) \tag{L.2b}$$

$$=\underline{m}_{\times}-\ 2.5\log_{10}\left(\tilde{\phi}(z)\right), \tag{L.2c}$$

where subscript $\times$ signifies 'as if the ROC effect were not inherent to GR' (as in the current "orthodox" interpretation of supernova observations), and $\tilde{\phi}$ denotes the multiplicative correction for the ROC effect. The $\cong$ sign in (L.2b) is practically an equal sign, because $\tilde{\phi}(z_{10\text{ pc}})$ is exceedingly near the value one and barely affects the scale of the absolute magnitude—so $\underline{M}_{\times}$ substitutes for $\underline{M}$. From (L.2b) to (L.2c) is an application of the "$\times$-counterpart" of (L.1). Unaware of the ROC effect, the current literature has mistaken $F_{\times}$ for F, $F_{\underline{M}\times}$ for $F_{\underline{M}}$, and thus $\underline{m}_{\times}$ for $\underline{m}$.

Combining (12) and (L.2c) gives

$$\underline{m}_{\text{CCE}}(ROC;\ z)\ \equiv\ \underline{m}_{\text{CCE}}(No\ ROC;\ z)+2.5\log_{10}\left(\frac{(1+z)^2+(1+z)^{-2}}{2}\right), \tag{L.3}$$

that is, equation (15), after we set $\underline{m}(z)=\underline{m}_{\text{CCE}}(ROC;\ z)$ and $\underline{m}_{\times}(z)=\underline{m}_{\text{CCE}}(No\ ROC;\ z)$.

Appendix M: 'Heisenberg' is nonrelativistic

It has been a misapprehension that the Heisenberg uncertainty principle is relativistic. In its derivation based on the Robertson uncertainty relation [i.e., (G.10)], the lower-bound is proportional to $\left\langle\left[\hat{r},\,\hat{p}\right]\right\rangle$, that is, to the *expectation value* of a normalized state's $\left[\hat{r},\,\hat{p}\right]$. Though $\left[\hat{r},\,\hat{p}\right]$ is relativistically invariant, the $\left\langle\left[\hat{r},\,\hat{p}\right]\right\rangle$ is not yet, in that the "orthodox" derivation of the Heisenberg uncertainty principle *omits* the relativistic dependence of the state's probability amplitude. In relativity, quantum-state normalization means $\langle\_|\_\rangle=\tilde{\phi}$.

Appendix N: Check of Lorentz-invariance

In the limit of 'classical' SR, that is, per (D.1) and (D.2) with tildes removed, inequality (18) becomes

$$\Delta(\tau)\Delta(m_0)\ \left(\equiv\sigma_{\text{PP}}\right)\ \geq\frac{\hbar}{2}, \tag{M.1}$$

which is a *necessary* condition of the (more dictating) 'proper' uncertainty principle (i.e., $\sigma_{\text{PP}}\geq\hbar$). Both $\Delta(\tau)$ and $\Delta(m_0)$ are Lorentz-invariant, and thereby so is (18).

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