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Posted Date: 27 September 2024

doi: 10.20944/preprints202207.0399.v77

Keywords: spacetime; cosmology; dark energy; quantum mechanics; entanglement; non-locality

Physics at a Crossroads: Weird Concepts or Orthogonal Projections

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Today's physics describes nature in "subjective concepts" (concepts of observers), such as spatial, temporal, wave, particle, force, field. There are coordinate-free formulations of special relativity (SR) and general relativity (GR), but there is no absolute time in SR/GR. Thus, there is no "holistic view" (view from all possible perspectives at the *same* instant in time). **I show:** Euclidean relativity (ER) provides a holistic view by describing nature in "objective concepts" (concepts that are immanent in all objects). "Pure distance" replaces spatial and temporal distance. "Pure energy" replaces wave and particle. I give one example where "process" replaces force and field. Each object's proper space d_1, d_2, d_3 and its proper time τ span a Euclidean 4D spacetime (ES), where d_1, d_2, d_3 and $d_4 = c\tau$ are pure distances. The new invariant is absolute, cosmic time θ. All energy moves through ES at the speed c. An observer's reality is created by orthogonally projecting ES to his proper space and to his proper time. The two projections are *reassembled* in SR/GR to form a non-Euclidean spacetime. Information is lost in all projections. Thus, there will always be unsolved mysteries if we ignore ES. **Physics now has two options:** (1) It rejects ER and continues with weird concepts (cosmic inflation, expanding space, dark energy, non-locality). (2) It accepts ER and solves 15 fundamental mysteries (including time's arrow and the Hubble constant tension) *without* these weird concepts. All solutions are purely geometrical. In particular, they require neither forces nor fields.

Keywords: spacetime; cosmology; dark energy; quantum mechanics; entanglement; non-locality

There are two legitimate approaches to describing nature: "subjective concepts" (concepts of observers) and "objective concepts" (concepts that are immanent in all objects). Subjective is what I observe. Objective is what all rulers and all clocks measure. Special relativity (SR)[1] and general relativity (GR)[2] take the first approach but do not provide a "holistic view" (view from all possible perspectives at the *same* instant in time). In SR/GR, there is no absolute time and thus no same instant in time. Euclidean relativity (ER) takes the second approach and provides a holistic view. Top journals rejected ER. I was often told that all physical theories must comply with SR/GR. This is not true because I disclose an issue in SR/GR. We must either disprove ER or accept ER. My message is: Subjectively, we live in a non-Euclidean spacetime. Objectively, we live in a Euclidean spacetime.

Nine pieces of advice: (1) *Make sure that you get it right.* I do not (!) disprove SR/GR. I show that the scope of SR/GR is limited. (2) *Do not reject ER unless you can provide a solid argument that disproves ER.* No one has provided such an argument yet. (3) *Do not evaluate ER with the concepts of SR/GR.* Theories must never be evaluated with the concepts of other theories. (4) *Do not confuse spacetime in ER with spacetime in SR/GR.* One reviewer claimed that my Euclidean diagrams must be false because spacetime is non-Euclidean in SR/GR. He is wrong!! This is as if he claimed that the heliocentric model must be false because the sun orbits Earth in the geocentric model. (5) *Be fair.* One paper cannot cover all of physics. SR/GR have been tested for decades. ER deserves the same chance. (6) *Be open to new ideas.* By postulating that my reality is a projection, ER surrenders dark energy and non-locality. (7) *Do not be prejudiced against a theory that solves many mysteries.* New concepts often do so. (8) *Appreciate illustrations.* As a geometric theory, ER complies with the stringency of math. (9) *Consider that you may be biased.* Some experts may feel offended.

To sum it all up: SR/GR make correct predictions but do not provide a holistic view. ER provides a holistic view, which is required for solving many mysteries. I apologize for my several preprint versions, but I received almost no support. My final version is all that is needed. The earlier versions show how I got there. It was tricky to figure out why SR/GR work so well despite an issue. Sect. 2 is about this issue. Sect. 3 describes ER. Sect. 4 covers geometric effects in ER. In Sect. 5, I outline the solutions to 15 mysteries.

 doi:10.20944/preprints202207.0399.v

1. Introduction

Today's concepts of space and time were coined by Albert Einstein. In SR, space and time are merged into a flat spacetime described by the Minkowski metric. SR is often presented in Minkowski spacetime because this concept illustrates the invariance of the spacetime interval very well.[3] Predicting the lifetime of muons[4] is an example that supports SR. In GR, curved spacetime is described by the Einstein tensor. The deflection of starlight[5] and the high accuracy of GPS[6] are examples that support GR. Quantum field theory[7] unifies classical field theory, SR, and quantum mechanics (QM) but not GR.

The postulates of ER: (1) All energy moves through 4D Euclidean spacetime (ES) at the speed of light c. (2) The laws of physics have the same form in each observer's reality. (3) An observer's reality is created by orthogonally projecting ES to his proper space and to his proper time. The two projections are *reassembled* in SR/GR to form a non-Euclidean spacetime. I will not discuss how this reassembly is done. Obviously, spacetime in SR/GR is non-Euclidean. Information is lost in all projections. Thus, there will always be unsolved mysteries if we ignore ES. My first postulate is stronger than the second SR postulate: c is absolute and universal. My second postulate refers to realities and not to inertial frames. My third postulate is unique. I also use objective concepts: "Pure distance" replaces spatial and temporal distance. "Pure energy" replaces wave and particle. To improve readability, all my observers are male. To make up for it, Mother Nature is female.

I call ES the "master reality" because each observer's reality is created by projecting ES. Fig. 1 left illustrates how ES relates to an observer's reality (a non-Euclidean reassembly of his proper space and his proper time). Fig. 1 right illustrates where to apply ER and where to apply SR/GR. ER describes ES and how each observer's reality is created. SR/GR describe each observer's reality and how the realities of two observers relate to each other. Note that ER describes nature but not an observer's reality!

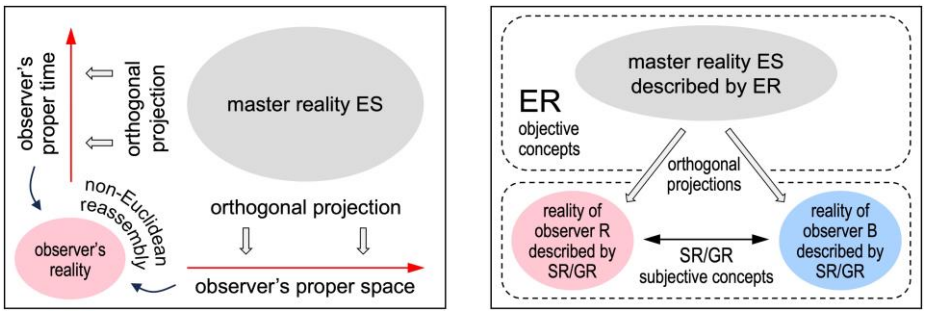

FIG. 1. Master reality ES and observer's reality. **Left:** Illustration of how ES relates to an observer's reality. **Right:** Illustration of where to apply ER and where to apply SR/GR.

Newburgh and Phipps pioneered ER.[8] Montanus claimed that a pure time interval would have to be a pure time interval for all observers.[9] According to Montanus,[10] this constraint is necessary to avoid the twin paradox and a character paradox (confusion of photons, particles, antiparticles). I show that the constraint is obsolete. *Whatever is proper time for me, it may be one axis of proper space for you.* There is no twin paradox if we consider cosmic time as the parameter. There is no character paradox if we consider "pure energy". Montanus tried to describe kinematics in ES using the Lagrange formalism.[11] Montanus even tried to formulate Maxwell's equations in ES but wondered about a wrong sign.[10] He overlooked that the SO(4) symmetry of ES is incompatible with waves. Montanus showed that ER predicts the same precession of Mercury's perihelion as GR.[10]

Almeida studied geodesics in ES.[12] Gersten showed that the Lorentz transformation is an SO(4) rotation in a "mixed space"[13] (see Sect. 3). van Linden maintains a website[14] about ER. Physicists are opposing ER because dark energy and non-locality make cosmology and QM work, waves are excluded, and paradoxes turn up if ER is expected to describe an observer's reality. This paper marks a turning point: I disclose an issue in SR/GR. I justify the exclusion of waves. I avoid paradoxes by projecting ES.

 doi:10.20944/preprints202207.0399.v

It is instructive to contrast Newton's physics, Einstein's physics, and ER. In Newton's physics, all energy moves through 3D Euclidean space as a function of independent time. There is no speed limit for matter. In Einstein's physics, all energy moves through 4D non-Euclidean spacetime. The speed of matter is $v_{3D} < c$. In ER, all energy moves through ES. The 4D speed of all energy is $u_{4D} = c$. Newton's physics[15] influenced Kant's philosophy.[16] Will ER reform both physics and philosophy?

2. Disclosing an Issue in Special and General Relativity

The fourth coordinate in SR is an observer's coordinate time t. In § 1 of SR, Albert Einstein provides an instruction on how to synchronize two clocks at the points P and Q. At t_P, a light pulse is sent from P to Q. At t_Q, the light pulse is reflected at Q. At t_P^*, the light pulse is back at P. The two clocks synchronize if

$$t_Q - t_P = t_P^* - t_Q \ . \tag{1}$$

In § 3 of SR, Einstein derives the Lorentz transformation. The coordinates x_1, x_2, x_3, t of an event in a system K are transformed to the coordinates x_1', x_2', x_3', t' in K′ by

$$x_1' = \gamma\,(x_1 - v_{3D}\,t) \ , \tag{2a}$$

$$x_2' = x_2 \ , \qquad x_3' = x_3 \ , \tag{2b}$$

$$t' = \gamma\,(t - v_{3D}\,x_1/c^2) \ , \tag{2c}$$

where K′ moves relative to K in x_1 at the constant speed v_{3D} and $\gamma = (1 - v_{3D}^2/c^2)^{-0.5}$ is the Lorentz factor. Mathematically, Eqs. (1) and (2a–c) are correct for observers in K. There are covariant equations for observers in K′. Physically, there is an issue in SR and also in GR: *The subjective concepts applied in SR and GR fail to solve fundamental mysteries of physics.* There are coordinate-free formulations of SR and GR,[17,18] but there is no absolute time in SR/GR. Thus, there is no "holistic view" (I repeat the important definition: view from all possible perspectives at the *same* instant in time). The view in SR/GR is not holistic but egocentric. Even all observers' views taken together do not make a holistic view because they still do not provide absolute time. Without absolute time, observers will not always agree on what is past and what is future. Physicists paid an enormous price for dismissing absolute time: ER restores absolute time (see Sect. 3) and solves 15 fundamental mysteries (see Sect. 5). Thus, the issue in SR/GR is not peanuts but real.

The issue in SR/GR is not about making wrong predictions. It has much in common with the issue in the geocentric model: In either case, there is no holistic view. Geocentrism is the egocentric view of mankind. In the old days, it was natural to believe that all celestial bodies would orbit Earth. Only the astronomers wondered about the retrograde loops of planets and claimed that Earth orbits the sun. In modern times, engineers have improved rulers and clocks. Today, it is natural to believe that it would be fine to describe nature as accurately as possible but from one or multiple egocentric perspectives. The human brain is smart, but it often takes itself as the center/measure of everything.

The analogy of SR/GR to the geocentric model is stunningly close: (1) It holds despite all covariances. After a transformation in SR/GR (or after appointing another planet as the center of the Universe), the perspective is again egocentric (or else geocentric). (2) ER has much in common with a "heliocentric model 2.0", where the sun is the center of our solar system but not of our galaxy. That model provides a holistic view from "beyond" (outside of) our galaxy. ER provides a holistic view from beyond an observer's reality. (3) We can make SR/GR and even (!) the geocentric model work—but only if we add weird concepts. Retrograde loops are obsolete—but only in the heliocentric model. Dark energy and non-locality are obsolete—but only in ER. (4) Heliocentrism was rejected in the old days. ER is rejected today. *Has physics not learned from history? Does history repeat itself?*

 doi:10.20944/preprints202207.0399.v

3. The Physics of Euclidean Relativity

The Minkowski metric in SR is often written as

$$c^2\,\mathrm{d}\tau^2 \;=\; c^2\,\mathrm{d}t^2 \;-\; \mathrm{d}x_1^2 \;-\; \mathrm{d}x_2^2 \;-\; \mathrm{d}x_3^2 \;, \tag{3}$$

where $\mathrm{d}\tau$ is an infinitesimal distance in proper time τ, whereas $\mathrm{d}t$ and $\mathrm{d}x_i$ $(i = 1, 2, 3)$ are infinitesimal distances in coordinate spacetime x_1, x_2, x_3, t. This spacetime is *construed* because coordinate space x_1, x_2, x_3 and coordinate time t are subjective concepts: They are not immanent in rulers/clocks but are construed by observers. Rulers measure proper length. Clocks measure proper time. I introduce ER by defining its metric

$$c^2\,\mathrm{d}\theta^2 \;=\; \mathrm{d}d_1^2 \;+\; \mathrm{d}d_2^2 \;+\; \mathrm{d}d_3^2 \;+\; \mathrm{d}d_4^2 \;, \tag{4}$$

where $\mathrm{d}\theta$ is an infinitesimal distance in cosmic time θ, whereas all $\mathrm{d}d_i$ $(i = 1, 2, 3)$ and $\mathrm{d}d_4 = c\,\mathrm{d}\tau$ are infinitesimal distances in 4D Euclidean spacetime d_1, d_2, d_3, d_4. The roles of θ and τ are switched: *The new invariant is absolute, cosmic time θ. The fourth coordinate is an object's proper time τ. The metric tensor is the identity matrix.* I prefer the indices 1–4 to 0–3 to stress the 4D symmetry. I choose the symbol θ because the initial of "theta" is "t". Each object's proper space d_1, d_2, d_3 and its proper time τ span ES, where d_1, d_2, d_3 and $d_4 = c\tau$ are pure distances. This spacetime is *natural* because all d_μ $(\mu = 1, 2, 3, 4)$ are objective concepts: They are immanent in rulers/clocks because all rulers/clocks measure d_μ. We must not confuse Eq. (4) with a Wick rotation,[19] where coordinate time t is imaginary and proper time τ remains the invariant parameter.

Each object is free to label the axes of ES. We assume that it labels the axis of its *current* 4D motion as d_4. Since it does not move in its proper space, it has to move in the d_4 axis at the speed c (my first postulate). Because of length contraction at the speed c, the d_4 axis disappears for itself and is experienced as proper time. Objects moving in the d_4' axis at the speed c experience this axis as proper time. *An object's proper time flows in the direction of its 4D motion.* Thus, there is a relative 4D vector "flow of proper time" $\boldsymbol{\tau}$.

$$\tau \;=\; d_4/c \;, \qquad \tau' \;=\; d_4'/c \;, \tag{5}$$

$$\boldsymbol{\tau} \;=\; d_4\,\boldsymbol{u}/c^2 \;, \qquad \boldsymbol{\tau}' \;=\; d_4'\,\boldsymbol{u}'/c^2 \;, \tag{6}$$

where $\boldsymbol{u}$ is an object's 4D velocity in ES. For all objects, there is $u_\mu = \mathrm{d}d_\mu/\mathrm{d}\theta$, where θ is absolute, cosmic time. Thus, Eq. (4) is equivalent to my first postulate.

$$u_1^2 \;+\; u_2^2 \;+\; u_3^2 \;+\; u_4^2 \;=\; c^2 \;. \tag{7}$$

My second postulate generalizes the principle of relativity to all realities. Since t is relative and θ is absolute, there is no continuous transition between Eqs. (3) and (4). *Thus, there is no continuous transition between SR and ER.* This is not an issue because SR describes nature subjectively in $x_1(\tau), x_2(\tau), x_3(\tau), t(\tau)$, where proper time τ is the parameter and t is coordinate time. ER describes nature objectively in $d_1(\theta), d_2(\theta), d_3(\theta), d_4(\theta)$, where cosmic time θ is the parameter and d_4 relates to τ according to Eq. (5). However, only in proper coordinates can we access ES. Is this perhaps an issue because the proper coordinates of other objects cannot be measured? In Sect. 6, I explain why this is not an issue. ER is a physical theory because it solves fundamental mysteries of physics.

It is instructive to contrast the three concepts of time. Coordinate time t is a subjective measure of time: An observer uses his clock as the master clock. Proper time τ is an objective measure of time: Clocks measure τ independently of observers. Cosmic time θ is the total distance covered in ES (length of a worldline) divided by c. By taking θ as the parameter, all observers will agree on what is past and what is future. Since cosmic time is absolute, there is no twin paradox in ER. *Twins are the same age in cosmic time.*

 doi:10.20944/preprints202207.0399.v

Let us compare SR with ER. We consider two identical clocks "r" (red clock) and "b" (blue clock). In SR, "r" moves in the ct axis. Clock "b" starts at $x_1 = 0$ and moves in the x_1 axis at a constant speed of $v_{3D} = 0.6\,c$. Fig. 2 left shows the instant when either clock moved 1.0 s in ct. Clock "b" moved 0.6 Ls (light seconds) in x_1 and 0.8 Ls in ct'. It displays "0.8". In ER, Fig. 2 right shows the instant when either clock moved 1.0 s in its proper time. Both clocks display "1.0". Clock "b" moved 0.6 Ls in d_1 and 0.8 Ls in d_4.

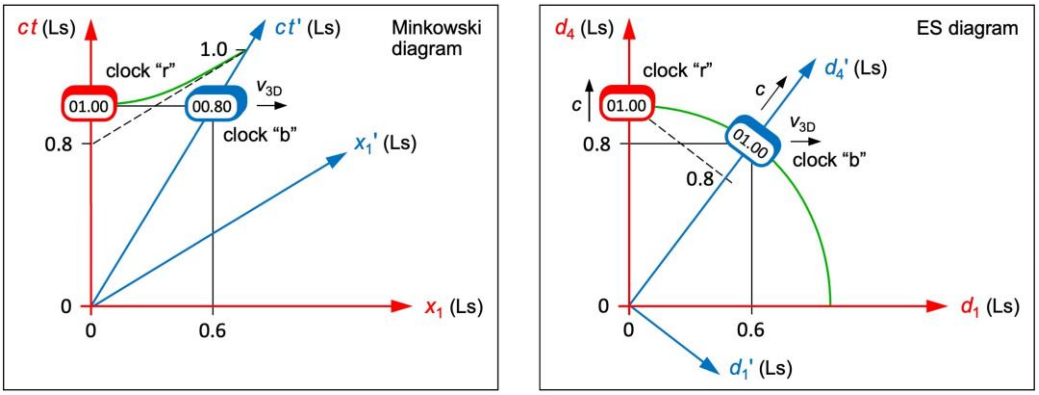

FIG. 2. Minkowski diagram and ES diagram of two identical clocks "r" (red) and "b" (blue). **Left:** In SR, "b" is slow with respect to "r" in t'. Coordinate time is relative ("b" is not at the same positions in ct and ct'). **Right:** In ER, "b" is slow with respect to "r" in d_4. Cosmic time is absolute ("r" is in d_4 at the same position as "b" in d_4'). Only the ES diagram is rotationally symmetric.

We now assume that an observer R (or B) is moving with the clock "r" (or else "b"). In SR and only from R's perspective, clock "b" is at $ct' = 0.8$ Ls when "r" is at $ct = 1.0$ Ls (see Fig. 2 left). Thus, "b" is slow with respect to "r" in t' (of B). In ER and independently of observers, clock "b" is at $d_4 = 0.8$ Ls when "r" is at $d_4 = 1.0$ Ls (see Fig. 2 right). Thus, "b" is slow with respect to "r" in d_4 (of R). *In SR and ER, "b" is slow with respect to "r", but time dilation occurs in different axes.* Experiments do not disclose the axis in which a clock is slow. Thus, SR and ER may claim that they describe time dilation correctly.

But why does ER provide a holistic view? Well, ES is independent of observers and thus absolute. This justifies the name "master reality". Only the projections from ES are relative. Absolute ES shows up in the rotational symmetry of all ES diagrams: Fig. 2 right works for R and for B *at once.* A second Minkowski diagram is required for B, where x_1' and ct' are orthogonal. The absoluteness also shows up in Eq. (4): All d_μ $(\mu = 1, 2, 3, 4)$ are interchangeable. Only observers experience distance as spatial or temporal.

Gersten showed that the Lorentz transformation is an SO(4) rotation in a "mixed space"[13] x_1, x_2, x_3, ct', where only ct' is primed. The four mixed coordinates x_1, x_2, x_3, ct' rotate to x_1', x_2', x_3', ct. I will not repeat the derivation. I consider it my task to turn ER into an accepted theory by revealing its power. However, a mixed space is physically pointless. In ER, unmixed d_1', d_2', d_3', d_4' rotate with respect to d_1, d_2, d_3, d_4 (see Sect. 4).

There is also a big difference in the synchronization of clocks: In SR, each observer is able to synchronize a uniformly moving clock to his clock (same value of ct in Fig. 2 left). If he does, these clocks are not synchronized from the perspective of the moving clock. In ER, clocks with the same 4D vector $\boldsymbol{\tau}$ are always synchronized, whereas clocks with different $\boldsymbol{\tau}$ and $\boldsymbol{\tau}'$ are never synchronized (different values of d_4 in Fig. 2 right).

4. Geometric Effects in Euclidean Relativity

We consider two identical rockets "r" (red rocket) and "b" (blue rocket). Let observer R (or B) be in the rear end of "r" (or else "b"). The 3D space of R (or B) is spanned by d_1, d_2, d_3 (or else d_1', d_2', d_3'). We use "3D space" as a synonym of "proper space". The proper time of R (or B) relates to d_4 (or else d_4') according to Eq. (5). Both rockets start at the point P and move relative to each other at the constant speed v_{3D}. R and B are free to label the

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axis of relative motion in 3D space. R (or B) labels it as d_1 (or else d_1'). The ES diagrams in Fig. 3 must fulfill my three postulates and the initial condition (same starting point P). This is achieved by rotating the red and the blue frame with respect to each other. Do not confuse my ES diagrams with Minkowski diagrams! *In ES diagrams, objects maintain proper length and clocks display proper time.* To improve readability, these diagrams show a rocket's width in d_4 (or d_4'). Fig. 3 bottom shows the projection to the 3D space of R (or B).

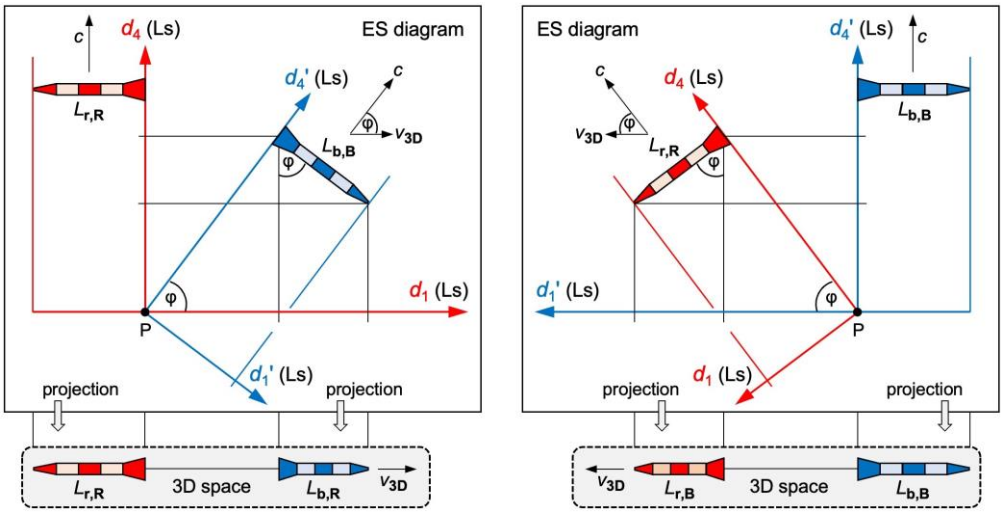

FIG. 3. ES diagrams and 3D projections of two rockets "r" (red) and "b" (blue). **Top:** Both rockets move in different 4D directions at the speed c. **Bottom left:** Projection to the 3D space of R. Rocket "b" contracts to $L_{\mathrm{b,R}}$. **Bottom right:** Projection to the 3D space of B. Rocket "r" contracts to $L_{\mathrm{r,B}}$.

Up next, we verify: (1) Rotating the red and the blue frame with respect to each other causes length contraction. (2) The fact that proper time flows in different 4D directions for R and for B causes time dilation. Let $L_{i,j}$ be the length of the rocket i for the observer j. In a first step, we project the blue rocket in Fig. 3 top left to the d_1 axis.

$$\sin^2\varphi + \cos^2\varphi = (L_{\mathrm{b,R}}/L_{\mathrm{b,B}})^2 + (v_{3\mathrm{D}}/c)^2 = 1\ , \tag{8}$$

$$L_{\mathrm{b,R}} = \gamma^{-1}\, L_{\mathrm{b,B}} \qquad \text{(length contraction)}, \tag{9}$$

where $\gamma = (1 - v_{3\mathrm{D}}^2/c^2)^{-0.5}$ is the same Lorentz factor as in SR. For observer R, rocket "b" contracts to $L_{\mathrm{b,R}}$. Which distances will R observe in his d_4 axis? We continue the rotation of "b" in Fig. 3 top left until it serves as a ruler for R in his d_4 axis. In the 3D space of R, this ruler contracts to a point: *The d_4 axis disappears for R because of length contraction at the speed c.* In a second step, we project the blue rocket in Fig. 3 top left to the d_4 axis.

$$\sin^2\varphi + \cos^2\varphi = (d_{4,\mathrm{B}}/d_{4,\mathrm{B}}')^2 + (v_{3\mathrm{D}}/c)^2 = 1\ , \tag{10}$$

$$d_{4,\mathrm{B}} = \gamma^{-1}\, d_{4,\mathrm{B}}'\ , \tag{11}$$

where $d_{4,\mathrm{B}}$ (or $d_{4,\mathrm{B}}'$) is the distance that B moved in d_4 (or else d_4'). With $d_{4,\mathrm{B}}' = d_{4,\mathrm{R}}$ (R and B cover the same distance in ES but in different directions), we calculate

$$d_{4,\mathrm{R}} = \gamma\, d_{4,\mathrm{B}} \qquad \text{(time dilation)}, \tag{12}$$

where $d_{4,\mathrm{R}}$ is the distance that R moved in d_4. Eqs. (9) and (12) tell us: γ is recovered in ER if we project ES to the axes d_1 and d_4 of an observer. The rockets in Fig. 3 serve as an example. Any other object is projected the same way to an observer's reality. Orthogonal projections are described in several textbooks.[20,21]

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Up next, we transform the proper coordinates of observer R to those of B. We recall that R (or B) is in the rear end of rocket "r" (or else "b"). We refer to Fig. 3 again, but we now calculate the 4D motion of R and of B as a function of the parameter θ. R and B start at the point P. The starting time is θ_0. R cannot measure the proper coordinates of B, and vice versa, but we can calculate them all by evaluating the ES diagrams in Fig. 3.

$$d_{1,\mathrm{R}}(\theta) = d_{1,\mathrm{R}}(\theta_0) \ , \tag{13a}$$

$$d_{2,\mathrm{R}}(\theta) = d_{2,\mathrm{R}}(\theta_0) \ , \qquad d_{3,\mathrm{R}}(\theta) = d_{3,\mathrm{R}}(\theta_0) \ , \tag{13b}$$

$$d_{4,\mathrm{R}}(\theta) = d_{4,\mathrm{R}}(\theta_0) + c\,(\theta - \theta_0) \ . \tag{13c}$$

$$d'_{1,\mathrm{B}}(\theta) = d'_{1,\mathrm{B}}(\theta_0) \ , \tag{14a}$$

$$d'_{2,\mathrm{B}}(\theta) = d'_{2,\mathrm{B}}(\theta_0) \ , \qquad d'_{3,\mathrm{B}}(\theta) = d'_{3,\mathrm{B}}(\theta_0) \ , \tag{14b}$$

$$d'_{4,\mathrm{B}}(\theta) = d'_{4,\mathrm{B}}(\theta_0) + c\,(\theta - \theta_0) \ . \tag{14c}$$

To transform the proper coordinates of R (unprimed) to the proper coordinates of B (primed), we have to take the rotation angle $90^0 - \varphi$ into account (see Fig. 3).

$$d'_{1,\mathrm{R}}(\theta) = d_{4,\mathrm{R}}(\theta)\,\cos\varphi = d_{4,\mathrm{R}}(\theta)\,v_{3\mathrm{D}}/c \ , \tag{15a}$$

$$d'_{2,\mathrm{R}}(\theta) = d_{2,\mathrm{R}}(\theta) \ , \qquad d'_{3,\mathrm{R}}(\theta) = d_{3,\mathrm{R}}(\theta) \ , \tag{15b}$$

$$d'_{4,\mathrm{R}}(\theta) = d_{4,\mathrm{R}}(\theta)\,\sin\varphi = d_{4,\mathrm{R}}(\theta)\,\gamma^{-1} \ . \tag{15c}$$

To understand how an acceleration manifests itself in ES, we return to our two clocks. Clock "r" and Earth move in the d_4 axis of "r" at the speed c (see Fig. 4), but clock "b" accelerates in the d_1 axis of "r" toward Earth while maintaining the speed c. Because of Eq. (7), the speed $u_{1,\mathrm{b}}$ of "b" in d_1 increases at the expense of its speed $u_{4,\mathrm{b}}$ in d_4.

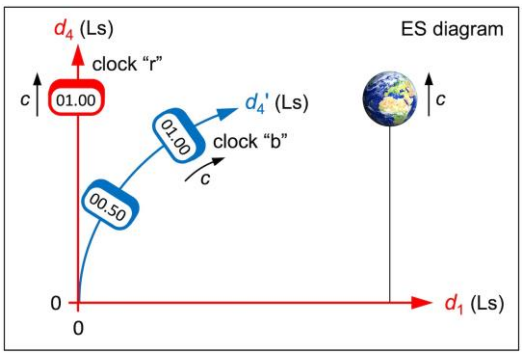

FIG. 4. ES diagram of two identical clocks "r" (red) and "b" (blue). Clock "r" and Earth move in the d_4 axis of "r" at the speed c. Clock "b" accelerates in the d_1 axis of "r" toward Earth.

Gravitational waves[22] support the idea of GR that gravity is a feature of spacetime. In ER, the SO(4) symmetry of ES is incompatible with waves. This is fine because wave is a subjective concept and thus described by SR/GR. However, an objective concept of force and field has yet to be defined which manifests itself as gravity or as another force in an observer's reality. A promising concept that replaces force and field is "process". Typical processes are the transfer of energy or momentum.[23] As an example, we now recover gravitational time dilation in ER. We consider the process "transfer of potential energy to kinetic energy". Initially, our clocks "r" and "b" are very far away from Earth. Eventually, "b" falls freely toward Earth as shown in Fig. 4. The kinetic energy of "b" in d_1 is

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$$\tfrac{1}{2}mu_{1,\mathrm{b}}^2 = GMm/R\ , \tag{16}$$

where m is the mass of "b", G is the gravitational constant, M is the mass of Earth, and R is the distance of "b" to Earth's center. By applying Eq. (7), we obtain

$$u_{4,\mathrm{b}}^2 = c^2 - u_{1,\mathrm{b}}^2 = c^2 - 2GM/R\ . \tag{17}$$

With $u_{4,\mathrm{b}} = \mathrm{d}d_{4,\mathrm{b}}/\mathrm{d}\theta$ ("b" moves in the d_4 axis at the speed $u_{4,\mathrm{b}}$) and $c = \mathrm{d}d_{4,\mathrm{r}}/\mathrm{d}\theta$ ("r" moves in the d_4 axis at the speed c), we calculate

$$\mathrm{d}d_{4,\mathrm{b}}^2 = (c^2 - 2GM/R)\,(\mathrm{d}d_{4,\mathrm{r}}/c)^2\ , \tag{18}$$

$$\mathrm{d}d_{4,\mathrm{r}} = \gamma_{\mathrm{gr}}\,\mathrm{d}d_{4,\mathrm{b}} \qquad \text{(gravitational time dilation)}, \tag{19}$$

where $\gamma_{\mathrm{gr}} = (1 - 2GM/(Rc^2))^{-0.5}$ is the same dilation factor as in GR. It does not depend on relative motion. Eq. (19) tells us: γ_{gr} is recovered in ER if we project ES to the d_4 axis of an observer. Since field is a subjective concept, there are no field equations in ER. More studies are required to confirm process as the objective concept of force and field.

Summary of time dilation: In SR, a uniformly moving clock "b" is slow with respect to "r" in the time dimension of "b". In GR, an accelerating clock "b" or a clock "b" in a stronger gravitational field is slow with respect to "r" in the time dimension of "b". In ER, a clock "b" is slow with respect to "r" in the time dimension of "r" (!) if the 4D vectors $\boldsymbol{\tau}$ of "r" and $\boldsymbol{\tau}'$ of "b" are not the same. Since both dilation factors γ and γ_{gr} are recovered in ER, the results of the Hafele–Keating experiment[24] do not only support SR/GR but also ER. Thus, GPS satellites work in ER as well as in SR/GR.

Three instructive problems teach us how to read ES diagrams correctly (see Fig. 5). Problem 1: In billiards, the blue ball is approaching the red ball. In ES, both balls move at the speed c. Let the red ball move in its d_4 axis. As the blue ball covers distance in d_1, its speed in d_4 must be less than c. *How can the balls ever collide if their d_4 values do not match?* Problem 2: A rocket moves along a guide wire. In ES, both objects move at the speed c. Let the wire move in its d_4 axis. As the rocket covers distance in d_1, its speed in d_4 must be less than c. *Doesn't the wire escape from the rocket?* Problem 3: Earth orbits the sun. In ES, both objects move at the speed c. Let the sun move in its d_4 axis. As Earth covers distance in d_1, d_2, its speed in d_4 must be less than c. *Doesn't the sun escape from Earth?*

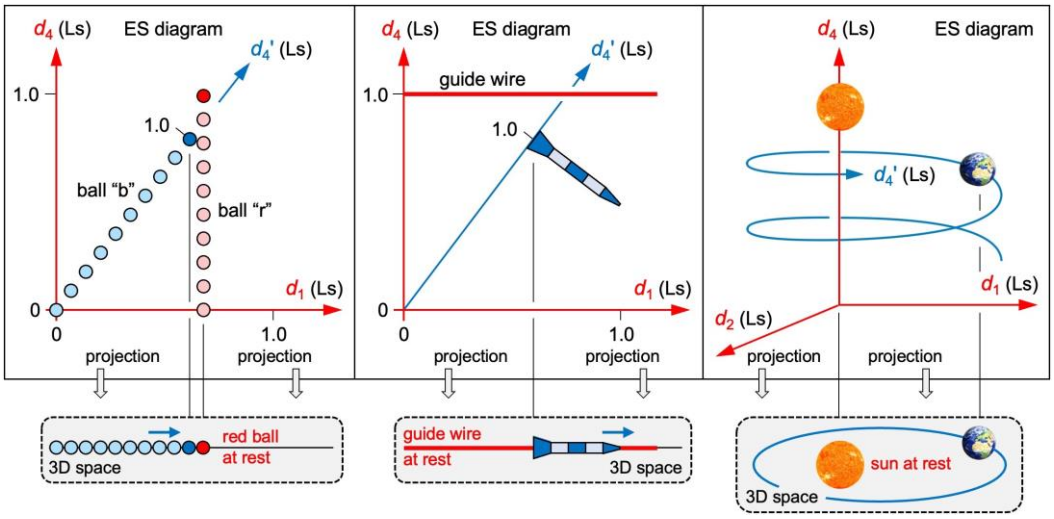

FIG. 5. Solving three instructive problems in ER. Each snapshot shows one instant in cosmic time. **Left:** The blue ball "b" is approaching the red ball "r". In the 3D space of "r", the balls collide. **Center:** A rocket moves along a wire. In the 3D space of the wire, the wire does not escape from the rocket. **Right:** Earth orbits the sun. In the 3D space of the sun, the sun does not escape from Earth.

 doi:10.20944/preprints202207.0399.v

The questions in the last paragraph seem to disclose geometric paradoxes in ER. The fallacy lies in the assumption that all four dimensions of ES would be spatial. We solve all problems by projecting ES to the 3D space of the object that moves in d_4 at the speed c. In its 3D space, it is at rest. We see the solutions in the ES diagrams, too, if we read them correctly: In Fig. 5 left, "r" and "b" collide if $d_{i,\mathrm{r}} = d_{i,\mathrm{b}}$ $(i = 1, 2, 3)$ and if the same cosmic time has elapsed for both balls ($d_{4,\mathrm{r}} = d'_{4,\mathrm{b}}$). Thus, a collision in 3D space does not show up as a collision in ES. This is reasonable because only three axes of ES are experienced as spatial. For the same reason, the wire (or the sun) does not *spatially* escape from the rocket (or else Earth). Wire and sun escape in the d_4 axis only, which disappears in the projection to 3D space. We must not confuse 4D Euclidean spacetime with a 4D Euclidean space. Only in the latter would the sun and Earth be casually disconnected.

5. Outlining the Solutions to 15 Fundamental Mysteries

We recall: (1) An observer's reality is a projection from ES. (2) Cosmic time θ is the correct parameter for a holistic view. In Sects. 5.1 through 5.15, I outline the solutions to 15 fundamental mysteries and declare four concepts of today's physics obsolete.

5.1. The Mystery of Time

Proper time τ is what clocks measure (d_4 divided by c). Cosmic time θ is the total distance covered in ES (length of a worldline) divided by c. An observer's clock always displays both quantities: his proper time τ and cosmic time θ.

5.2. The Mystery of Time's Arrow

Time's arrow is a synonym for "time moving only forward". The arrow emerges from the fact that covered distance (d_4 or total distance) cannot decrease but only increase.

5.3. The Mystery of the Factor c^2 in the Energy Term mc^2

In SR, if forces are absent, the total energy E of an object is given by

$$E = \gamma mc^2 = E_{\mathrm{kin,3D}} + mc^2 \,, \tag{20}$$

where $E_{\mathrm{kin,3D}}$ is its kinetic energy in an observer's 3D space and mc^2 is called its "energy at rest". SR does not tell us why there is a factor c^2 in the energy of objects that in SR do not move at the speed c. ER gives us the missing clue: The object is never at rest but moves in its d'_4 axis. From the object's perspective, $E_{\mathrm{kin,3D}}$ is zero and mc^2 is its kinetic energy in d'_4. The factor c^2 is a hint that it moves through ES at the speed c. In SR, there is

$$E^2 = p^2 c^2 = p_{3\mathrm{D}}^2 c^2 + m^2 c^4 \,, \tag{21}$$

where p is the total momentum of an object and $p_{3\mathrm{D}}$ is its momentum in an observer's 3D space. Again, ER is eye-opening: From the object's perspective, $p_{3\mathrm{D}}$ is zero and mc is its momentum in d'_4. The factor c is a hint that it moves through ES at the speed c.

5.4. The Mystery of Length Contraction and Time Dilation

In SR, length contraction and time dilation can be derived from the Lorentz transformation, but their cause remains in the dark. ER discloses that length contraction and time dilation stem from projecting ES to the axes d_1 and d_4 of an observer.

5.5. The Mystery of Gravitational Time Dilation

In GR, gravitational time dilation stems from a curved spacetime. ER discloses that it stems from projecting curved worldlines in a flat ES to the d_4 axis of an observer. Eq. (7) tells us: *If an object accelerates in an observer's proper space, it automatically decelerates in his proper time.* More studies are required to understand other gravitational effects in ER.

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5.6. The Mystery of the Cosmic Microwave Background (CMB)

In Sects. 5.6 through 5.12, I outline an ER-based model of cosmology. ES is a mathematical manifold and timeless like numbers. In particular, ES is not inflating/expanding. For some reason, there was a Big Bang. In the inflationary Lambda-CDM model, the Big Bang occurred "everywhere" (space inflated from a singularity). In the ER-based model, the Big Bang is locatable (a huge amount of energy was injected into ES at some origin O). Cosmic time θ is the time that has elapsed since the Big Bang. *The Big Bang was a singularity in providing energy and radial momentum.* At $\theta = 0$, all energy started moving radially away from O. Shortly thereafter, the concentration of pure energy (objective concept, see Sect. 5.13) was very high. In any 3D space, plasma particles (subjective concept) were created. Recombination radiation was emitted that we observe as CMB today.[25]

The ER-based model must be able to answer these questions: (1) Why is the CMB so isotropic? (2) Why is the temperature of the CMB so low? (3) Why do we still observe the CMB today? Here are some possible answers: (1) The CMB is so isotropic because it has been scattered equally in the 3D space d_1, d_2, d_3 of Earth. (2) The temperature of the CMB is so low because the plasma particles had a very high recession speed v_{3D} (see Sect. 5.7) shortly after the Big Bang. (3) The CMB has been scattered multiple times in d_1, d_2, d_3 and reaches Earth after having covered the same distance in d_1, d_2, d_3 as Earth in d_4.

5.7. The Mystery of the Hubble–Lemaître Law

In Fig. 6 left, Earth and a galaxy G recede from the origin O of ES. In Earth's 3D space, G recedes from Earth at the 3D speed v_{3D}. According to my first postulate, v_{3D} relates to the 3D distance D of G to Earth as c relates to the radius r of a 4D hypersphere.

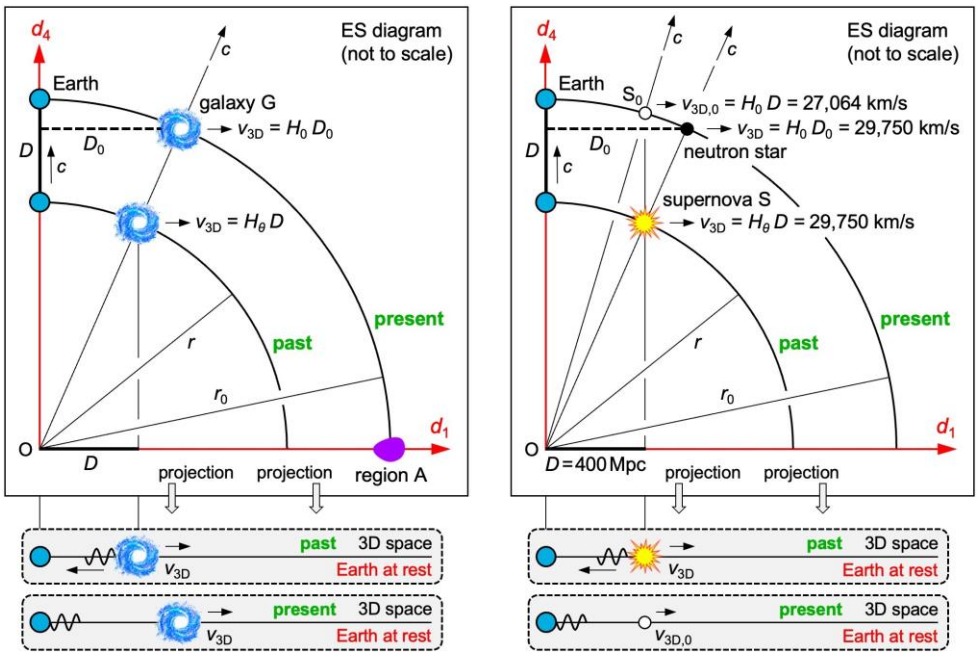

FIG. 6. ER-based model of cosmology. The circular arcs are part of an expanding 3D hypersurface. **Left:** Galaxy G recedes from the location of the Big Bang (origin O of ES) at the speed c, and from the d_4 axis in particular at the 3D speed v_{3D}. **Right:** If star S_0 happens to be at the same distance D today at which the supernova of star S occurred, S_0 recedes more slowly from Earth than S.

$$v_{3D} = D\,c/r = H_\theta\,D\ , \tag{22}$$

where $H_\theta = c/r = 1/\theta$ is the Hubble parameter. If we observe G today at the cosmic time θ_0, the recession speed v_{3D} and c remain unchanged. Thus, Eq. (22) turns into

$$v_{3D} = D_0\,c/r_0 = H_0\,D_0\ , \tag{23}$$

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where $H_0 = c/r_0 = 1/\theta_0$ is the Hubble constant, $D_0 = D\, r_0/r$ is today's 3D distance of G to Earth, and r_0 is today's radius of the 4D hypersphere. Eq. (23) is the Hubble–Lemaître law.[26,27] Cosmologists are aware of the Hubble parameter and of the quantity "cosmic time". They are not aware yet that the 4D geometry is Euclidean, that Eq. (23) refers to D_0 rather than to D, and that there is no acceleration. Out of any two galaxies, the one farther away recedes faster, but each galaxy maintains its 3D speed v_{3D}.

5.8. The Mystery of the Flat Universe

For each observer, ES is orthogonally projected to his proper space and to his proper time. Thus, he experiences two seemingly discrete structures: a flat 3D space and time.

5.9. The Mystery of Cosmic Inflation

Many cosmologists[28,29] claim that an inflation of space shortly after the Big Bang explains the isotropic CMB, the flat universe, and large-scale structures. The latter inflated from quantum fluctuations. I just showed that ER explains the first two effects. ER even explains large-scale structures if the impacts of quantum fluctuations have been expanding like the 4D hypersphere. ***In ER, cosmic inflation is an obsolete concept.***

5.10. The Mystery of Cosmic Homogeneity (Horizon Problem)

How can the universe be so homogeneous if there are casually disconnected regions of space? In the Lambda-CDM model, a region A at $x_1 = +r_0$ and a region B at $x_1 = -r_0$ are casually disconnected unless we postulate a cosmic inflation. Without it, information could not have covered $2r_0$ since the Big Bang. ER solves the problem without a cosmic inflation: In Fig. 6 left, A is at $d_1 = +r_0$ and B is at $d_1 = -r_0$ (not shown). From A's or B's perspective, their d_4' axis (equal to Earth's d_1 axis) disappears because of length contraction at the speed c. *A and B are casually connected because they overlap spatially in either reality.* Their opposite 4D vectors $+\boldsymbol{\tau}'$ and $-\boldsymbol{\tau}'$ do not affect casual connectivity.

5.11. The Mystery of the Hubble Constant Tension

Up next, I explain why the published values of the Hubble constant H_0 do not match each other (also known as the "Hubble constant tension"). I compare data of CMB measurements (Planck space telescope) with data of calibrated distance ladder measurements (Hubble space telescope). According to team A,[30] there is $H_0 = 67.66 \pm 0.42$ km/s/Mpc. According to team B,[31] there is $H_0 = 73.04 \pm 1.04$ km/s/Mpc. Team B made efforts to minimize the error margins in the distance measurements, but a systematic error in team B's calculation of H_0 arises from assuming a wrong cause of the redshifts.

Let us assume that team A's value of H_0 is correct. We simulate the supernova of a star S that occurred at a distance of $D = 400$ Mpc from Earth (Fig. 6 right). The recession speed v_{3D} of S is calculated from measured redshifts. The redshift parameter $z = \Delta\lambda/\lambda$ tells us how each wavelength λ of the supernova's light is either stretched by an expanding space (team B) or else Doppler-redshifted by receding objects (ER-based model). The supernova occurred at the cosmic time θ (arc called "past"), but we observe it at the cosmic time θ_0 (arc called "present"). While the supernova's light moved the distance D in d_1, Earth moved the same distance D but in d_4 (my first postulate). There is

$$1/H_\theta \;=\; r/c \;=\; (r_0 - D)/c \;=\; 1/H_0 \;-\; D/c\;. \qquad (24)$$

For a very short distance of $D = 400$ kpc, Eq. (24) tells us that H_θ deviates from H_0 by only 0.009 percent. However, when plotting v_{3D} versus D for distances from 0 Mpc to 500 Mpc in steps of 25 Mpc (red points in Fig. 7), the slope of a straight-line fit through the origin is roughly 10 percent greater than H_0. Since team B calculates H_0 from similar but mirrored plots (magnitude versus z), its value of H_0 is roughly 10 percent too high. *This solves the Hubble constant tension.* Team B's value is not correct because, according to Eq. (23), we must plot v_{3D} versus D_0 (blue points in Fig. 7) to get a straight line.

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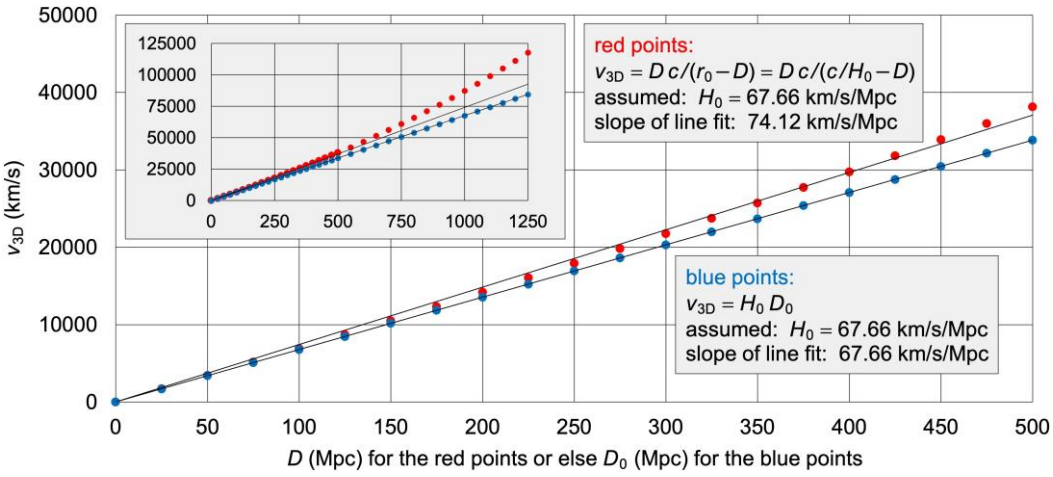

FIG. 7. Hubble diagram of simulated supernovae at distances up to 1250 Mpc. The horizontal axis is D for the red points or else D_0 for the blue points. The red points were calculated from Eq. (22). They do not yield a straight line because H_θ is not a constant. The blue points were calculated from Eq. (23). They yield a straight line if we do not confuse D_0 with D.

Since we cannot measure D_0 (observable magnitudes relate to D rather than to D_0), the easiest way to fix the calculation of team B is to rewrite Eq. (23) as

$$v_{3D,0} = D\,c/r_0 = H_0\,D \ , \tag{25}$$

where $v_{3D,0}$ is today's 3D speed of another star S_0 (Fig. 6 right) that happens to be at the same distance D today at which the supernova of star S occurred. I kindly ask team B to recalculate H_0 after converting all v_{3D} to $v_{3D,0}$. To perform this conversion, we only have to combine Eq. (24) with Eq. (25) and then with Eq. (22). This gives us

$$H_\theta = H_0\,c/(c - H_0\,D) = H_0/(1 - v_{3D,0}/c) \ , \tag{26}$$

$$v_{3D,0} = v_{3D}/(1 + v_{3D}/c) \ . \tag{27}$$

By applying Eq. (27) and plotting $v_{3D,0}$ versus D, all red points in Fig. 7 drop down to the blue points. Fig. 7 does not only solve the Hubble constant tension. It also explains why the H_0 tension increases if high-redshift data are included:[31] The higher the value of the redshift parameter z is, the more v_{3D} deviates from a straight line. The moment of the supernova is irrelevant to team B's calculation of H_0. All that counts in the Lambda-CDM model is the duration of the light's journey to Earth. The parameter z continuously increases during the journey. In the ER-based model, all that counts is the moment of the supernova. Each wavelength is initially redshifted by the Doppler effect. Here z remains constant during the journey. It was specified at the moment of the supernova and is eventually measured on Earth. Space is not expanding. Rather, energy is receding from O (the location of the Big Bang in ES). ***In ER, expanding space is an obsolete concept.***

5.12. The Mystery of Dark Energy

Team B can fix the systematic error in its calculation of H_0 by converting all v_{3D} to $v_{3D,0}$ according to Eq. (27). I now reveal another systematic error, but it is inherent in the Lambda-CDM model. It stems from assuming an accelerating expansion of space and can be fixed only by replacing this model with the ER-based model unless we postulate a dark energy. Many cosmologists[32,33] advocate an accelerating expansion because the calculated recession speeds v_{3D} deviate from a straight line in the Hubble diagram and these deviations increase with D. An accelerating expansion would indeed stretch each wavelength even further and thus explain the increasing deviations.

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In ER, the increasing deviations are much easier to understand: The older the redshift data are, the more H_θ deviates from H_0, and the more v_{3D} deviates from $v_{3D,0}$. If another star S_0 (Fig. 6 right) happens to be at the same distance of $D = 400$ Mpc today at which the supernova of star S occurred, Eq. (27) tells us: S_0 recedes more slowly (27,064 km/s) from Earth than S (29,750 km/s). As long as cosmologists are not aware of the 4D Euclidean geometry, they attribute the deviations to an accelerating expansion of space caused by "dark energy".[34] Dark energy has not been confirmed yet. It is a stopgap for an effect that the Lambda-CDM model cannot explain. Older supernovae recede faster not because of an accelerating expansion but because of a larger H_θ in Eq. (22).

The Hubble constant tension and dark energy are solved exactly the same way: *In Eq. (23), we must not confuse* D_0 *with* D. Because of Eq. (22) and $H_\theta = c/(r_0 - D)$, the recession speed v_{3D} is not proportional to D but to $D/(r_0 - D)$. This is why the red points in Fig. 7 run away from a straight line. Any expansion of space (uniform or else accelerating) is only virtual. There is no accelerating expansion of space even if the Nobel Prize in Physics 2011 was given "for the discovery of the accelerating expansion of the Universe through observations of distant supernovae".[35] There are two misconceptions in these words of praise: (1) In the Lambda-CDM model, Universe implies space, but space is *not* expanding. (2) There is *no* acceleration. All but the nearest galaxies recede from Earth, but they do so uniformly. ***In ER, dark energy is an obsolete concept.***

This result casts doubt on the Lambda-CDM model but not on GR. We have to accept that objective concepts are mandatory in cosmology. Radial momentum provided by the Big Bang drives all galaxies away from the origin O of ES. They are driven by themselves rather than by dark energy. Table I compares two models of cosmology. Note that "Universe" and "universe" are not the same thing! Observers may indeed experience different "universes". In Sects. 5.6 through 5.12, objective concepts improve our understanding of cosmology. In the next two sections, they also prove very useful in QM.

Inflationary Lambda-CDM model based on GR	ER-based model of cosmology
The Big Bang was the beginning of the Universe.	The Big Bang was an injection of energy into ES.
The Big Bang occurred "everywhere".	The Big Bang can be localized (origin O of ES).
There are two competing values of H_0.	H_0 is approximately 67–68 km/s/Mpc.
The "Universe": all space, all time, and all energy.	The "universe": an observer's proper space.
Spacetime is non-Euclidean.	Spacetime is Euclidean.
There is no absolute time.	Cosmic time is absolute.
Shortly after the Big Bang, space was inflating.	There is no inflation of space.
Today, there is an accelerating expansion of space.	There is no expansion of space.
Space is driven by dark energy.	Galaxies are driven by radial momentum.
Dark energy has not yet been confirmed.	There is no dark energy.

TABLE I. Comparing two different models of cosmology.

5.13. The Mystery of the Wave–Particle Duality

The wave–particle duality was first discussed by Niels Bohr and Werner Heisenberg and has bothered physicists ever since.[36] Electromagnetic waves are oscillations of an electromagnetic field, which propagate through an observer's 3D space at the speed c. In some experiments, objects behave like waves. In other experiments, the very same objects behave like particles (also known as the "wave–particle duality"). In today's physics, one object cannot be wave and particle at once because the energy of a wave is distributed in space, whereas the energy of a particle is always localized in space.

We solve the duality by introducing two objective concepts: "Pure distance" replaces spatial and temporal distance. "Pure energy" replaces wave and particle. My neologism "wavematter" visualizes pure energy (see Fig. 8). In an observer's reality (external view), a wavematter appears as a wave packet or as a particle. As a wave, it propagates in his x_1 axis at the speed c and it oscillates in his axes x_2 and x_3 (electromagnetic field). Since

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here we talk about an observer's reality, the wave propagates and oscillates as a function of coordinate time. In its own reality (internal view), the axis of the wavematter's 4D motion disappears because of length contraction at the speed c. It deems itself particle at rest. "Wavematter" is not just a substitute word for the duality. Rather, it visualizes an objective concept of energy that takes the internal view of photons into account.

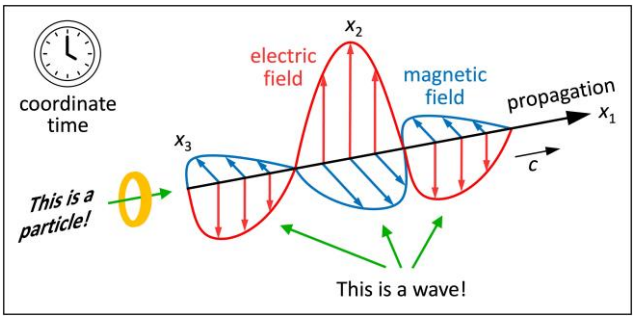

FIG. 8. Illustration of a wavematter. In an observer's reality (external view), a wavematter appears as a wave packet or as a particle. As a wave (shown here), it propagates and oscillates as a function of coordinate time. In its own reality (internal view), the axis of the wavematter's 4D motion disappears because of length contraction at the speed c. It deems itself particle at rest.

Like spatial and temporal distance, wave and particle are subjective concepts: *What I deem wave, deems itself particle at rest.* For each wavematter, its own energy condenses (concentrates) to what we call "mass". Albert Einstein taught us that energy is equivalent to mass.[37] Likewise, the polarization of a wave is equivalent to the spin of a particle. It is this very equivalence that inspired me to coin the word "wavematter".

In a double-slit experiment, wavematters pass through a double-slit and produce an interference pattern on a screen. An observer deems them wave packets as long as he does not track through which slit each wavematter is passing. *Here the external view applies.* The photoelectric effect is different. Of course, I can externally witness how a photon releases an electron from a metal surface, but the physical effect is all up to the photon: The electron is released only if the photon energy exceeds the electron's binding energy. *Here the internal view of the photon is the crucial view.* The photon behaves like a particle.

The wave–particle duality is also observed in matter, such as electrons.[38] Electrons, too, are wavematters. They behave like waves as long as they are not tracked. If they are tracked, they behave like particles. Since an observer automatically tracks objects that are slow in his 3D space, he deems all slow objects—and thus all macroscopic objects—matter rather than waves. To improve readability, I do not draw wavematters in my ES diagrams. I draw what they are deemed by observers: clocks, rockets, galaxies, etc.

5.14. The Mystery of Entanglement

The word "entanglement" was coined by Erwin Schrödinger in his comment[39] on the Einstein–Podolsky–Rosen paradox.[40] These authors argued that QM would not provide a complete description of reality. Schrödinger's neologism did not solve the paradox, but it demonstrates our difficulties in comprehending QM. John Bell showed that QM is incompatible with local hidden-variable theories.[41] Meanwhile, it has been confirmed in several experiments[42–44] that entanglement violates locality in an observer's 3D space. Entanglement has been considered a non-local effect ever since.

Up next, I show that there is no violation in four dimensions. All we need to untangle entanglement is ER: Non-locality becomes obsolete because all four d_μ $(\mu = 1, 2, 3, 4)$ are interchangeable. Fig. 9 illustrates two wavematters that were created at once at a point P. They move away from each other in opposite 4D directions $\pm d_4'$ at the speed c. It turns out that they are automatically entangled. For an observer moving in any direction other than $\pm d_4'$ (external view), the two wavematters are spatially separated. The observer has no idea how they are able to "communicate" with each other in no time.

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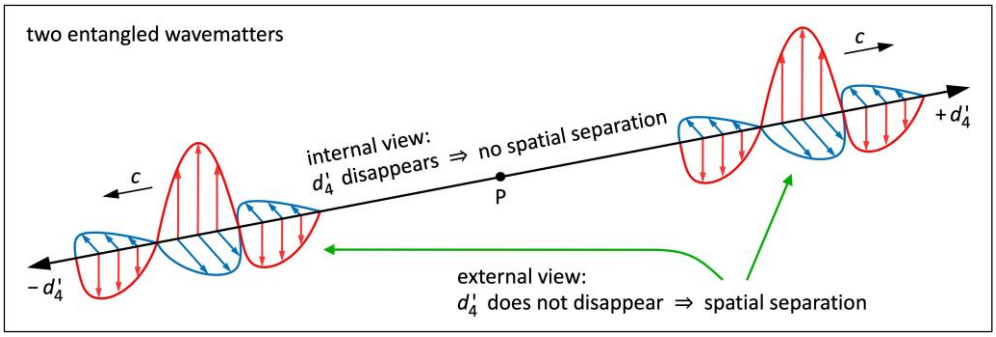

FIG. 9. Two wavematters moving in $\pm d_4'$ at the speed c are spatially separated for an observer moving in any direction other than $\pm d_4'$ (external view). For each wavematter (internal view), the d_4' axis disappears. From the internal view, the twins have never been separated spatially.

For each wavematter (internal view), the d_4' axis disappears because of length contraction at the speed c. In their common (!) proper space spanned by d_1', d_2', d_3', either of them is at the same position as its twin. From the internal view, the twins have never been separated spatially, but their proper time flows in opposite 4D directions. While the twins stay together spatially, they "communicate" with each other in no time. Their opposite 4D vectors $+\boldsymbol{\tau}'$ and $-\boldsymbol{\tau}'$ do not affect local "communication". There is a "spooky action at a distance" (phrase attributed to Einstein) from the external view only.

This time, the horizon problem and entanglement are solved exactly the same way: *An observer's 4D vector* $\boldsymbol{\tau}$ *and his proper space may differ from an observed region's (object's) 4D vector* $\boldsymbol{\tau}'$ *and its proper space.* This is possible only if all d_μ $(\mu = 1, 2, 3, 4)$ are interchangeable. ER also explains the entanglement of matter, such as electrons.[45] In an observer's proper space, electrons move at a speed $v_{3D} < c$. In their $\pm d_4'$ axis, electrons move at the speed c. Any measurement tilts the axis of 4D motion of one twin and thus destroys the entanglement. ***In ER, non-locality is an obsolete concept.***

5.15. The Mystery of the Baryon Asymmetry

In the Lambda-CDM model, almost all matter was created shortly after the Big Bang. Only then was the temperature high enough to enable pair production. However, baryons and antibaryons should have annihilated each other because the energy density, too, was very high. Fact is that we observe more baryons than antibaryons today (also known as the "baryon asymmetry"). Pair production creates equal amounts of baryons and antibaryons. So, what caused the asymmetry? ER scores again: *Each wavematter injected by the Big Bang deems itself particle at rest.* The asymmetry was caused by the Big Bang.

But why do wavematters not deem themselves antiparticles at rest? Well, antiparticles are created in pair production only. They are not the opposite of particles but particles with the opposite electric charge. In particular, there is a reasonable "character paradox": *What I deem antiparticle, deems itself particle.* It only seems that antiparticles flow backward in time because proper time flows in opposite 4D directions for any two wavematters created in pair production. In ER, these wavematters are automatically entangled. This gives us a chance to falsify ER. All scientific theories must be falsifiable.[46]

6. Conclusions

ER solves mysteries that have not been solved yet (time's arrow, Hubble constant tension) and mysteries that have been solved but only by adding weird concepts: cosmic inflation, expanding space, dark energy, non-locality. I showed that these concepts are obsolete in ER. Weird concepts make cosmology and QM work, but Occam's razor shaves them off. Occam's razor tells us that obsolete concepts should always be surrendered. Physics now has two options: (1) It rejects ER and continues with all these weird concepts. (2) It accepts ER and solves 15 fundamental mysteries *without* these weird concepts. All solutions are purely geometrical. In particular, they require neither forces nor fields.

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SR/GR are considered two of the greatest achievements of physics because they have been confirmed over and over. I showed that SR/GR do not provide a holistic view. Physics got stuck in its own concepts. The stagnation in physics is of its own making. It is very unlikely that 15 solutions in different (!) areas of physics are 15 coincidences. *Only in natural concepts does Mother Nature disclose her secrets.* If we think of each observer's reality as an oversized stage, the key to understanding nature is beyond all stages. I advise physics to teach ER and to apply objective concepts in cosmology and QM.

It was a wise decision to award Albert Einstein the Nobel Prize for his theory of the photoelectric effect[47] and not for SR/GR. I showed that ER penetrates to a deeper level. Einstein—one of the most brilliant physicists ever—failed to realize that the fundamental metric chosen by Mother Nature is Euclidean. Einstein sacrificed absolute space and time. ER restores absolute, cosmic time, but it sacrifices the absolute nature of wave and particle. For the first time ever, mankind understands the nature of time: Cosmic time is the total distance covered in ES divided by c. *The human brain is able to imagine that we move through ES at the speed* c. With that said, conflicts of mankind become all so small.

Is ER a physical or a metaphysical theory? This is a very good question because only in proper coordinates can we access ES, but the proper coordinates of other objects cannot be measured. Make sure that you get it right: Rulers/clocks do measure d_μ $(\mu = 1, 2, 3, 4)$, but I cannot measure d'_μ of other objects. However, I can calculate them as I did in Eqs. (13a–15c). Physics is the science of describing the universe and its interior. Our primary source of knowledge is observing, but observing is always wedded to egocentric perspectives. We must not limit physics to observing. If we do, even cosmology and QM would be metaphysical theories because neither dark matter nor wave functions are observable. ER is a physical theory because it solves fundamental mysteries of physics.

Final remarks: (1) I only touched on gravity. We should not reject ER because gravity is still an issue. GR seems to solve gravity, but GR is incompatible with QM unless we add more speculative concepts (quantum gravity). (2) I only touched on processes. In Sect. 4, I gave one example. More studies are required to confirm process as the objective concept of force and field. (3) Mysteries, such as the retrograde loops of planets, often disappear if we choose the appropriate symmetry. The SO(4) symmetry of ES is the appropriate symmetry in cosmology and QM. (4) The new invariant "cosmic time" puts an end to all speculations about time travel. Does any other theory solve time's arrow as beautifully as ER? (5) To cherish its beauty, we must work with ER. Physics does not ask: Why is my reality a projection? Nor does it ask: Why is it a wave function? Projections are less speculative than dark energy and non-locality. (6) It looks like Plato's *Allegory of the Cave*[48] is correct: Mankind experiences projections that are blurred—because of QM.

It is not by chance that the author is an experimental physicist whose primary question is: How does all our insight fit together without adding highly speculative concepts? I laid the groundwork for ER and showed how powerful it is. Paradoxes are only virtual. The true pillars of physics are ER, SR/GR (for each observer's reality), and QM. Together, they describe everything from the very large to the very small. Introducing a holistic view to physics is what I consider my most significant contribution: All observers' views taken together do not make a holistic view. The holistic view holds additional information that is hidden in absolute time and thus not available in SR/GR. Everyone is welcome to solve even more mysteries. May ER get the broad acceptance that it deserves!

Acknowledgements: I thank Siegfried W. Stein for his contributions to Sect. 5.11 and for the Figs. 3, 5 center, and 6 (partly). After several unsuccessful submissions, he eventually decided to withdraw his co-authorship. I also thank Matthias Bartelmann, Dirk Rischke, Jürgen Struckmeier, and Andreas Wipf for asking questions and commenting. In particular, I thank all reviewers and editors for the precious time that they spent on grappling with my manuscript.

Comments: It takes open-minded, courageous editors and reviewers to evaluate a theory that heralds a paradigm shift. Whoever adheres to established concepts is paralyzing the scientific progress. I did not surrender when top journals rejected my theory. Interestingly, I was never given any solid

arguments that would disprove my theory. Rather, I was asked to try a different journal. Were the editors dazzled by the success of SR/GR? Did they underestimate the benefits of ER? It seems to me that most editors were afraid of considering a new theory that opposes the mainstream. Even friends refused to support me. Anyway, each setback inspired me to work out the benefits of ER even better. Finally, I succeeded in disclosing a physical issue in SR/GR and also in formulating a holistic theory of relativity that is even more general than Albert Einstein's "general" relativity.

Some physicists have difficulties in accepting ER because the SO(4) symmetry of ES is incompatible with waves. ER is not disputing waves but limiting their occurrence to an observer's reality. A well-known preprint archive suspended my submission privileges. I was penalized because I disclosed an issue in Einstein's theories of relativity. One editor was unable to imagine that the Hubble constant tension is solved without GR. One editor-in-chief replied: "Publishing is for experts only." I do not blame anyone. Paradigm shifts are always hard to accept. These comments shall encourage young scientists to stand up for promising ideas even if opposing the mainstream is hard work. Peer reviewers considered my theory "unscholarly research", "fake science", and "too simple to be true". *Simplicity and truth are not mutually exclusive. Beauty is when they go hand in hand together.*

Conflict of interest: The author has no conflicts to disclose.

Data availability: The data that support the findings of this study are available within the article.

Funding: No funds, grants, or other support was received.

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