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Euclidean Relativity Solves the Hubble Constant Tension

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Einstein's special relativity (SR) and general relativity (GR) describe nature in "subjective concepts" (concepts of an observer), such as relative spacetime, wave, particle, and force. Despite the Lorentz covariance of SR and the general covariance of GR, an observer's perspective is always egocentric. Coordinate-free formulations of SR/GR or multiple egocentric perspectives do not provide a "holistic view of nature" (comprehensive view of nature from all possible perspectives at the same instant in time) because there is no absolute time in SR/GR. **Here I show:** Euclidean relativity (ER) describes nature in "objective concepts" (concepts that are immanent in all objects). "Pure distance" replaces spatial and temporal distance. "Pure energy" replaces wave and particle. Each object's proper space d_1, d_2, d_3 and its proper time τ span an absolute 4D Euclidean spacetime (ES), where d_1, d_2, d_3 and $d_4 = c\tau$ are pure distances. All energy moves through ES at the speed of light c. An object's proper time flows in the direction of its 4D motion. Thus, there is a relative 4D vector "flow of proper time". The invariant parameter is absolute, cosmic time t. An observer's reality is created by projecting ES orthogonally to his proper space and to his proper time. *ER neither competes with nor replaces SR/GR. ER complements SR/GR by adding a holistic view.* ER describes the "master reality" ES, whereas SR/GR describe an observer's reality. The holistic view solves 15 fundamental mysteries geometrically, in particular in cosmology and quantum mechanics. Examples are time's arrow, the horizon problem, the Hubble constant tension, dark energy, entanglement, and the baryon asymmetry.

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

This paper introduces holistic thinking to physics. There are two approaches to describing nature: in "subjective concepts" (concepts of an observer) or else in "objective concepts" (concepts that are immanent in all objects). Only the second approach provides a "holistic view of nature" (comprehensive view of nature from all possible perspectives at the same instant in time). Special relativity (SR) and general relativity (GR) take the first approach (Einstein, 1905b; Einstein, 1916). Euclidean relativity (ER) takes the second approach. Top journals in physics rejected my theory. Often, I was told that manuscripts are not considered if they challenge SR/GR. This is not how science works! Many hints tell us that SR/GR cannot be the full story. Here is the message of my paper: Subjectively, we live in a curved, non-Euclidean spacetime. Objectively, we live in a flat, Euclidean spacetime.

Seven pieces of advice: (1) *Do not take SR/GR as the ultimate truth.* Correct predictions do not prove SR/GR. ER predicts the same relativistic effects as SR/GR. (2) *Do not expect to recover Einstein's field equations in ER.* Several editors and reviewers did so. ER describes a master reality beyond all fields. Physical fields come into play in an observer's reality only. (3) *Be patient and be fair.* One paper cannot cover all of physics. SR and GR have been tested for 100+ years. ER deserves the same chance. (4) *Do not reject ER on some knee-jerk reaction.* A rejection requires solid arguments that disprove ER. Why not cherish the beauty of ER? (5) *Do not be prejudiced against a theory that solves many mysteries.* New concepts often do so. (6) *Appreciate illustrations.* As a geometric theory, ER complies with the stringency of math. (7) *Consider that you may be biased.* Some concepts of today's physics are obsolete in ER. As an expert in such a concept, you may feel offended. If your concepts do not fit to ER, you may want to consider seeing our world through different eyes (Niemz, 2020).

To sum it up: SR and GR work well in each observer's reality, but they do not provide a holistic view. ER provides a holistic view, which is required for the solution of the Hubble constant tension and other mysteries. I do 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 recovers both the Lorentz factor and gravitational time dilation. In Sect. 5, ER solves 15 mysteries of physics.

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1. Introduction

Today's concepts of space and time were coined by Albert Einstein. In SR, he merges them into a flat spacetime described by an indefinite distance function. SR is often presented in Minkowski spacetime because it illustrates the invariance of the spacetime interval very well (Minkowski, 1910). Predicting the lifetime of muons (Rossi & Hall, 1941) is an example that supports SR. In GR, curved spacetime is described by a pseudo-Riemannian metric. Predicting the deflection of starlight (Dyson et al., 1920) and the high accuracy of GPS (Ashby, 2003) are examples that support GR. Quantum field theory (Ryder, 1985) unifies classical field theory, SR, and quantum mechanics (QM) but not GR.

Two postulates of ER: (1) All energy moves through 4D Euclidean spacetime (ES) at the speed of light. (2) The laws of physics have the same form in each "observer's reality", which is created by projecting ES orthogonally to his proper space and to his proper time. To improve readability, all of my observers are male. To make up for it, nature is female. My first postulate is stronger than the second postulate of SR: The speed of light c is absolute and universal. My second postulate refers to realities rather than to inertial frames. I also introduce two objective concepts. "Pure distance" replaces spatial and temporal distance. "Pure energy" replaces wave and particle.

Newburgh and Phipps (1969) pioneered ER. Montanus (1991) described an absolute Euclidean spacetime with a "preferred frame of reference" (a pure time interval is a pure time interval for all observers). Montanus (2023) claims: Without the preferred frame, we would face the twin paradox and a "character paradox" (confusion of photons, particles, antiparticles). I will show that the preferred frame is obsolete. Whatever is proper time for me, it may be proper space for you. There is no twin paradox if absolute time is taken as the parameter. There is no character paradox if the concept "pure energy" is applied. Montanus (2001) tried to formulate kinematic equations in ES using the Lagrange formalism. Montanus (2023) even tried to formulate Maxwell's equations in ES but wondered about a wrong sign. He overlooked that the SO(4) symmetry of ES is incompatible with waves. Note that there are waves and particles in an observer's reality but not in ES.

Almeida (2001) investigated geodesics in ES. Gersten (2003) showed that the Lorentz transformation is an SO(4) rotation in "mixed space" (see Sect. 3). van Linden (2023) runs a website about various ER models. Physicists are still opposed to ER because dark energy and non-locality make cosmology and QM work, waves are excluded, and paradoxes may turn up if ER is not interpreted correctly. *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.

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 (Newton, 1687) influenced Kant's philosophy (Kant, 1781). I predict that ER will reform 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, Einstein provides an instruction on how to synchronize two clocks at P and Q. At t_P, a light pulse is sent from P to Q. At t_Q, it is reflected. At t_P^*, it is back at P. The 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

$$x_1' = \gamma\,(x_1 - v_{3D}\,t) \ , \quad x_2' = x_2 \ , \quad x_3' = x_3 \ , \tag{2a}$$

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

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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–b) are correct for observers in K. There are covariant equations for observers in K′. Physically, there is an issue in SR and in GR: *They fail to solve various mysteries of physics.* Despite the Lorentz covariance of SR and the general covariance of GR, an observer's perspective is always egocentric. Coordinate-free formulations of SR/GR or multiple egocentric perspectives do not provide a holistic view of nature because there is no absolute time in SR/GR—and thus no "same instant in time" as required in a holistic view. Without absolute time, observers will not always agree on what is past and what is future. Physics has paid a high price for dismissing absolute time: ER restores absolute time (see Sect. 3) and solves 15 mysteries of physics (see Sect. 5). Thus, the issue in SR/GR is real. *However, ER neither competes with nor replaces SR/GR. ER complements SR/GR by adding a holistic view.* ER describes the "master reality" ES, whereas SR/GR describe an observer's reality.

The issue in SR/GR has much in common with the issue in the geocentric model: In either case, there is no holistic view. Geocentrism is nothing but the egocentric perspective 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 the precision of rulers and clocks. Eventually, it was natural to believe that it would be fine to describe nature as accurately as possible but from one or more egocentric perspectives. The human brain is very smart, but it often deems itself 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 each observer's reality. (3) 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 still being rejected today. *Have physicists not learned from history? Does history repeat itself?*

3. The Physics of Euclidean Relativity

The indefinite distance function in SR is usually 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 distance. Clocks measure proper time. I introduce ER by defining its metric

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

where $\mathrm{d}t$ is an infinitesimal distance in cosmic time t, 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 (ES). In ER, the roles of t and τ are switched: *The invariant parameter is cosmic time t. The fourth coordinate is an object's proper time τ. The metric tensor is the identity matrix.* I retain the symbol t because it is the initial of "time". I prefer the indices 1–4 over 0–3 to stress the symmetry. 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 (proper distance and proper time). We must not confuse Eq. (4) with a Wick rotation (Wick, 1954), where coordinate time t is imaginary and proper time τ remains the invariant parameter.

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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" $\boldsymbol{\tau}$.

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

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

where $\boldsymbol{u}$ is an object's 4D velocity in ES. For all objects, there is $u_\mu = \mathrm{d}d_\mu/\mathrm{d}t$, where t is 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 revises the principle of relativity and also defines an observer's reality. Since coordinate time t in Eq. (3) is not equal to cosmic time t in Eq. (4), there is *no continuous transition* between SR and ER. In SR, an object is described by the four coordinates $x_1(\tau), x_2(\tau), x_3(\tau), t(\tau)$, where proper time τ is the parameter and t is coordinate time. In ER, an object is described by the four coordinates $d_1(t), d_2(t), d_3(t), d_4(t)$, where cosmic time t is the parameter and d_4 relates to τ according to Eq. (5).

It is instructive to contrast three concepts of time. Coordinate time t is a subjective measure of time: It is equal to $\tau = |\boldsymbol{\tau}|$ for the observer only. Proper time τ is an objective measure of time: Clocks measure τ independently of observers. Finally, cosmic time t is the total distance covered in ES (length of a geodesic) divided by c. By taking cosmic time as the parameter, all observers 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.* However, ER also seems to have an issue (see Sect. 6 why it is not an issue): Only in proper coordinates can we access ES, but the proper coordinates of other objects cannot be measured. By the way: ER is not a "problem" that a Lagrangian or Hamiltonian could solve. ER is an innovative, geometric description of nature based on a Euclidean metric.

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. 1 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. 1 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.

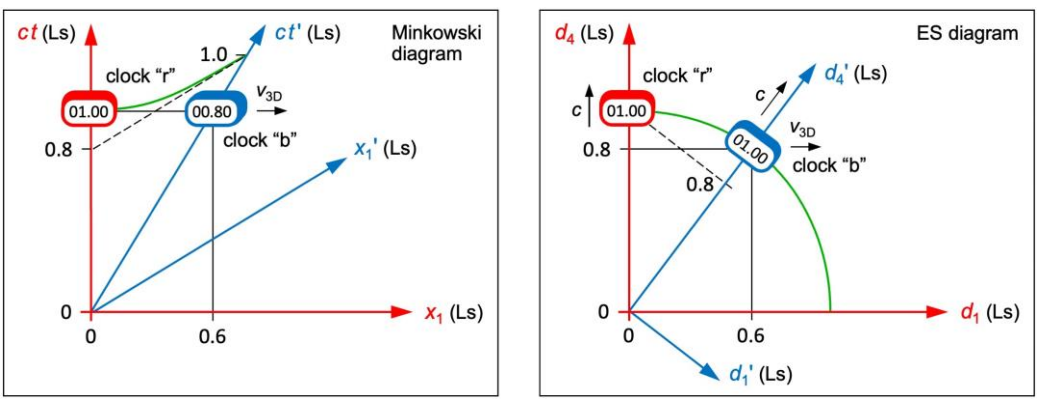

Figure 1. Minkowski diagram and ES diagram of two identical clocks "r" (red) and "b" (blue). **Left:** In SR, "b" is slow with respect to "r" in t'. Coordinate time is relative ("b" is not at the same positions in ct and ct'). **Right:** In ER, "b" is slow with respect to "r" in d_4. Cosmic time is absolute ("r" is in d_4 at the same position as "b" in d_4'). Only the ES diagram is rotationally symmetric.

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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. 1 left). Thus, "b" is slow with respect to "r" in t' (of B). In ER and independent of observers, clock "b" is at $d_4 = 0.8$ Ls when "r" is at $d_4 = 1.0$ Ls (see Fig. 1 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 is why I call ES the "master reality". Only the projections from ES are relative. The absolute nature of ES shows up in the rotational symmetry of all ES diagrams: Fig. 1 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 are interchangeable. Only observers experience distance as spatial or temporal.

Gersten (2003) showed that the Lorentz transformation is an SO(4) rotation in "mixed space" 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. 1 left). If he does, the two clocks are not synchronized from the perspective of the moving clock. In ER, clocks with the same $\boldsymbol{\tau}$ are always synchronized, whereas clocks with different $\boldsymbol{\tau}$ and $\boldsymbol{\tau}'$ are never synchronized (different values of d_4 in Fig. 1 right).

4. Geometric Effects in 4D Euclidean Spacetime

We consider two identical rockets "r" (red rocket) and "b" (blue rocket). Let observer R (or B) be in the rear end of rocket "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'). "3D space" is a synonym of "proper space". The proper time of R (or B) relates to d_4 (or else d_4'). Both rockets started at a point P and move relative to each other at the constant speed v_{3D}. We are free to label the axis of motion in 3D space. We label it as d_1 (or d_1'). The ES diagrams in Fig. 2 must fulfill my two postulates and the initial condition (starting point P). We achieve this by rotating the red and the blue frame with respect to each other. To improve readability, I draw a rocket's width in d_4 (or d_4'). Actually, it is in d_2, d_3 (or d_2', d_3'). Fig. 2 bottom shows the projection to the 3D space of R (or B). *In all ES diagrams, objects maintain proper length and clocks display proper time.*

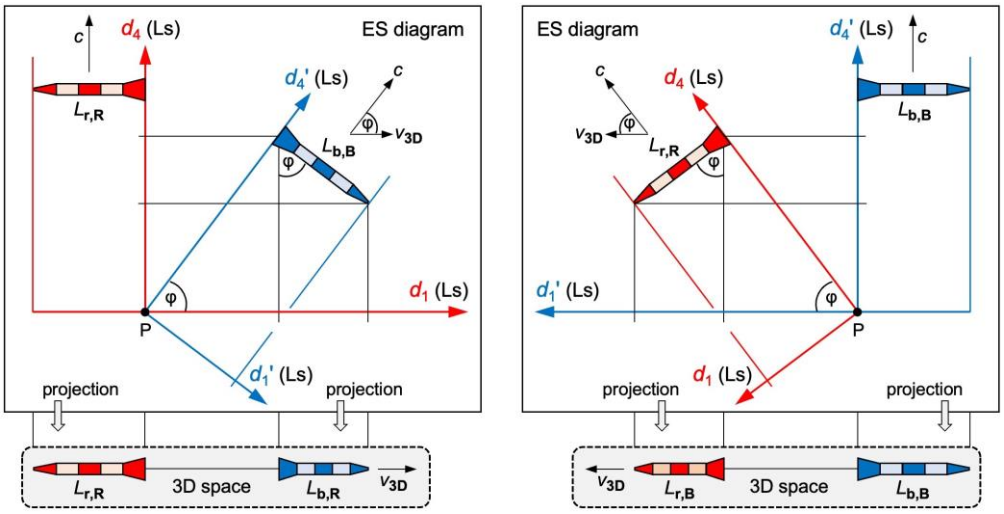

Figure 2. ES diagrams and 3D projections of two rockets "r" (red) and "b" (blue). **Top:** Both rockets move in different 4D directions at the speed c. **Bottom left:** Projection to the 3D space of R. Rocket "b" contracts to $L_{b,R}$. **Bottom right:** Projection to the 3D space of B. Rocket "r" contracts to $L_{r,B}$.

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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. The rotations are not a surprise. Weyl (1928) showed that the Lorentz group is generated by 4D rotations. Let $L_{i,j}$ be the length of rocket i for observer j. In a first step, we project the blue rocket in Fig. 2 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 $L_{\mathrm{b,R}}$. We now ask: Which distances will R observe in his d_4 axis? We mentally continue the rotation of rocket "b" in Fig. 2 top left until it serves as a ruler for R in his d_4 axis. In the projection to the 3D space of R, this ruler contracts to zero: 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. 2 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: SR works so well because γ is recovered if we project ES to the axes d_1 and d_4 of an observer.

To understand how an acceleration manifests itself in ES, we return to our two clocks "r" and "b" (Fig. 3). We assume that "r" and Earth move in the d_4 axis of "r" at the speed c and that "b" accelerates in the d_1 axis of "r" toward Earth. 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.

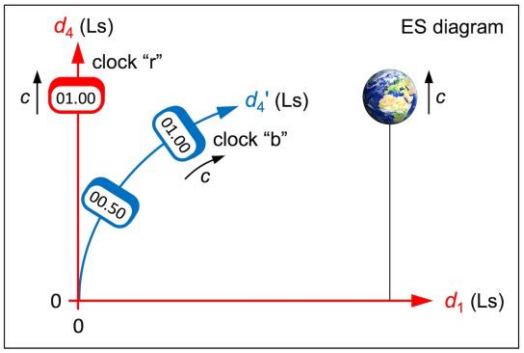

Figure 3. ES diagram of two identical clocks "r" (red) and "b" (blue). Clock "r" and Earth move in the d_4 axis of "r" at the speed c. Clock "b" accelerates in the d_1 axis of "r" toward Earth.

Gravitational waves (Abbott et al., 2016) 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 not an issue if we limit their occurrence to an observer's reality. There are no waves in ES. As in classical physics, I consider gravity a force that has not yet been unified with the other three forces. I can imagine that the unification will succeed if force, too, is replaced by an objective concept. Up next, I recover gravitational time dilation in ER. I base my derivation on energy rather than force. Initially, our clocks shall be far away from Earth. Eventually, "b" falls freely toward Earth as shown in Fig. 3. The kinetic energy of "b" in d_1 is

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$$\tfrac{1}{2}mu_{1,\mathrm{b}}^2 \;=\; GMm/r \;, \tag{13}$$

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

$$u_{4,\mathrm{b}}^2 \;=\; c^2 \;-\; u_{1,\mathrm{b}}^2 \;=\; c^2 \;-\; 2GM/r \;. \tag{14}$$

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

$$\mathrm{d}d_{4,\mathrm{b}}^2 \;=\; (c^2 \;-\; 2GM/r)\,(\mathrm{d}d_{4,\mathrm{r}}/c)^2 \;, \tag{15}$$

$$\mathrm{d}d_{4,\mathrm{r}} \;=\; \gamma_{\mathrm{gr}}\,\mathrm{d}d_{4,\mathrm{b}} \qquad \text{(gravitational time dilation)}, \tag{16}$$

where $\gamma_{\mathrm{gr}} = (1 - 2GM/(rc^2))^{-0.5}$ is the same dilation factor as in GR. Eq. (16) tells us: GR works so well because γ_{gr} is recovered if we project ES to the d_4 axis of an observer. As in GR, the dilation factor γ_{gr} does not depend on relative motion.

Summary of time dilation: In SR, a uniformly moving clock "b" is slow with respect to a clock "r" in the proper time of "b". In GR, an accelerating clock "b" or a clock "b" in a stronger gravitational field is slow with respect to a clock "r" in the proper time of "b". In ER, a clock "b" is slow with respect to a clock "r" in the proper time of "r" (!) if the d_4' axis of "b" does not coincide with the d_4 axis of "r". That is, if "b" moves relative to "r" (uniformly or non-uniformly) or if "b" is in a stronger gravitational field. Since both factors γ and γ_{gr} are recovered in ER, the Hafele–Keating experiment (1972) supports ER too. Thus, GPS satellites work in ER just as well as in GR.

Three instructive problems demonstrate how to read ES diagrams correctly (Fig. 4). 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's orbit?*

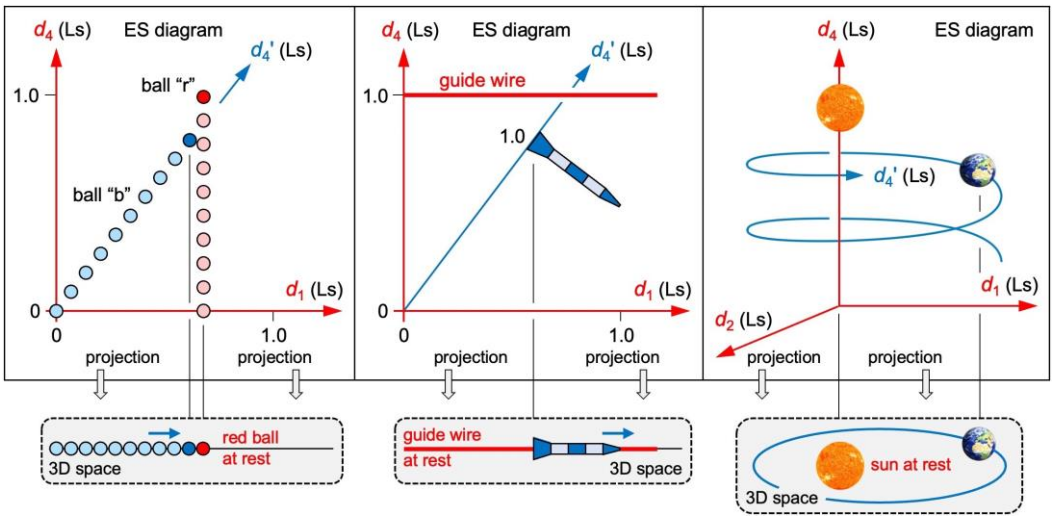

Figure 4. Solving three instructive problems in ER. Each snapshot shows one instant in cosmic time. **Left:** The blue ball "b" is approaching the red ball "r". In the projection, the balls collide. **Center:** A rocket moves along a guide wire. In the projection, the wire does not escape from the rocket. **Right:** Earth orbits the sun. In the projection, the sun does not escape from Earth's orbit.

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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: For instance, the balls "r" and "b" in Fig. 4 left collide if $d_{i,\mathrm{r}} = d_{i,\mathrm{b}}$ $(i = 1, 2, 3)$ and if the same proper 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 out of four dimensions are deemed spatial by an observer.

5. Solving 15 Fundamental Mysteries of Physics

We recall: (1) An observer's reality is created by projecting ES orthogonally to his proper space and to his proper time. (2) There is a relative 4D vector $\boldsymbol{\tau}$. (3) Cosmic time t is the correct parameter for a holistic view. In Sects. 5.1 through 5.15, ER solves 15 fundamental mysteries and declares five concepts of today's physics obsolete.

5.1. Solving the Mystery of Time

Proper time τ is what clocks measure. Cosmic time t is the total distance covered in ES divided by c. For each observer, proper time and cosmic time run the same. Only for him does his clock also measure cosmic time. Any observed clock is slow with respect to his clock in his proper time (ER) or else in the observed clock's proper time (SR/GR).

5.2. Solving 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. Solving 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

$$E = \gamma mc^2 = E_{\mathrm{kin,3D}} + mc^2 , \tag{17}$$

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

$$E^2 = p^2 c^2 = p_{3\mathrm{D}}^2 c^2 + m^2 c^4 , \tag{18}$$

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. Solving the Mystery of Length Contraction and Time Dilation

In SR, length contraction and time dilation can be derived from the Lorentz transformation, but their physical 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. Solving the Mystery of Gravitational Time Dilation

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

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

In Sects. 5.6 through 5.12, I outline an "ER-based model of cosmology". Distances are like numbers. In particular, they are not inflating/expanding. For some reason, there was a Big Bang. In the inflationary Lambda-CDM model based on GR, the Big Bang occurred "everywhere" because space inflated from a singularity. In the ER-based model, the Big Bang can be localized: It injected a huge amount of energy into ES at once at an origin O, the only natural reference point in ES. The Big Bang occurred at the cosmic time $t = 0$. It was a singularity in terms of providing energy and radial momentum. All energy started moving radially at the speed c. Shortly after the Big Bang, energy was highly concentrated in ES. In the projection to any 3D space, a very hot and dense plasma was created. While the plasma was expanding, it cooled down. Cosmic recombination radiation was emitted that we still observe as CMB today (Penzias & Wilson, 1965).

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. Solving the Mystery of the Hubble–Lemaître Law

In Fig. 5 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.

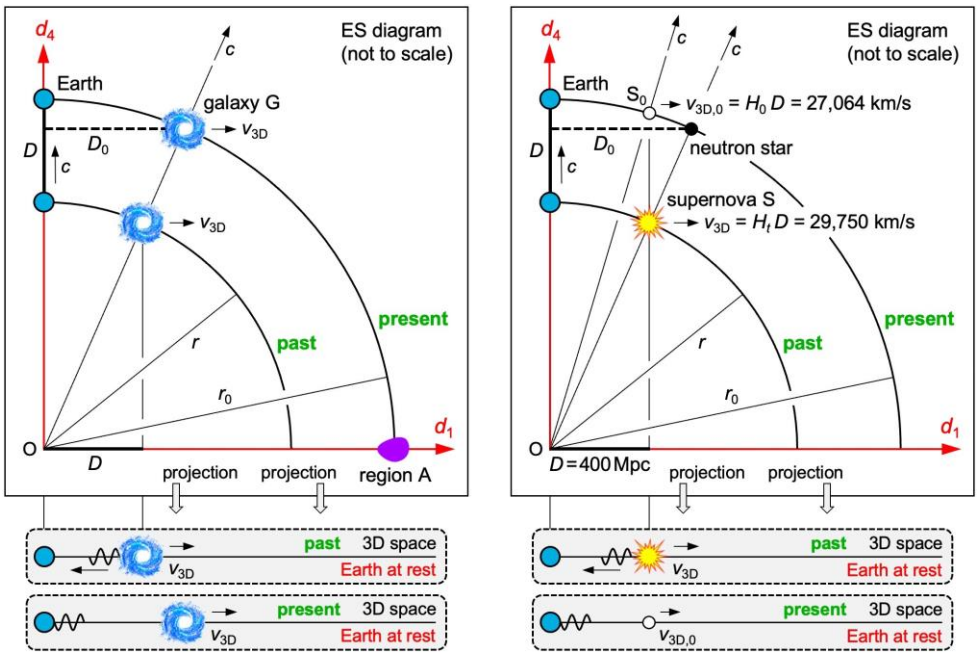

Figure 5. ER-based model of cosmology. The circular arcs are part of an expanding 3D hypersurface. **Left:** Galaxy G recedes from Earth at the 3D speed v_{3D}. **Right:** If star S_0 happens to be at the same distance from Earth today as the supernova of star S in the past, S_0 recedes more slowly than S.

$$v_{3D} = D\,c/r = H_t\,D\ , \tag{19}$$

where $H_t = c/r = 1/t$ is the Hubble parameter. If we observe G today at the cosmic time $t = t_0$, the recession speed v_{3D} and c remain unchanged. Thus, Eq. (19) turns into

$$v_{3D} = D_0\,c/r_0 = H_0\,D_0\ , \tag{20}$$

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where $H_0 = c/r_0 = 1/t_0$ 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. (20) is the Hubble–Lemaître law (Hubble, 1929; Lemaître, 1927): The farther a galaxy is, the faster it recedes from Earth. Cosmologists are aware of the parameter H_t. They are not yet aware that the 4D geometry is Euclidean and that we must use D_0 in Eq. (20) rather than D.

5.8. Solving the Mystery of the Flat Universe

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

5.9. Solving the Mystery of Cosmic Inflation

Many cosmologists believe that the isotropic CMB, the flat universe, and large-scale structures (inflated from quantum fluctuations) are best explained by an inflation of space shortly after the Big Bang (Linde, 1990; Guth, 1997). As I just showed, ER also explains the first two effects. ER explains large-scale structures if the quantum fluctuations have been expanding like the 4D hypersphere. ***In ER, cosmic inflation is an obsolete concept.***

5.10. Solving the Mystery of Cosmic Homogeneity (Horizon Problem)

The horizon problem is a fine-tuning 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 a distance of $2r_0$ since the Big Bang. ER solves the problem without a cosmic inflation: In Fig. 5 left, region A is at $d_1 = +r_0$. Region B is at $d_1 = -r_0$ (not shown). From A's or B's perspective, their d_4' axis (which is 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.*

5.11. Solving the Mystery of the Hubble Constant Tension

Up next, I explain why the published values of H_0 do not match (also known as the "Hubble constant tension"). I compare CMB measurements (Planck space telescope) with calibrated distance ladder measurements (Hubble space telescope). According to team A (Aghanim et al., 2020), there is $H_0 = 67.66 \pm 0.42$ km/s/Mpc. According to team B (Riess et al., 2018), there is $H_0 = 73.52 \pm 1.62$ km/s/Mpc. Team B made efforts to minimize the error margins in the distance measurements, but assuming a wrong cause of the redshifts gives rise to a systematic error in team B's calculation of H_0.

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. 5 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 *passively stretched* by an expanding space (team B)—or else redshifted by the Doppler effect of *actively receding objects* (ER-based model). The supernova occurred at the cosmic time t (arc called "past"), but we observe it at the cosmic time t_0 (arc called "present"). Thus, all redshift data stem from a cosmic time $t < t_0$ with $r < r_0$ and $H_t > H_0$. While the supernova's light moved the distance D in d_1, Earth moved the same D in d_4 (my first postulate). There is

$$1/H_t \;=\; r/c \;=\; (r_0 - D)/c \;=\; 1/H_0 \;-\; D/c\ . \qquad (21)$$

For a very short distance of $D = 400$ kpc, Eq. (21) tells us that H_t 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. 6), 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. (20), we must plot v_{3D} versus D_0 (blue points in Fig. 6) to get a straight line.

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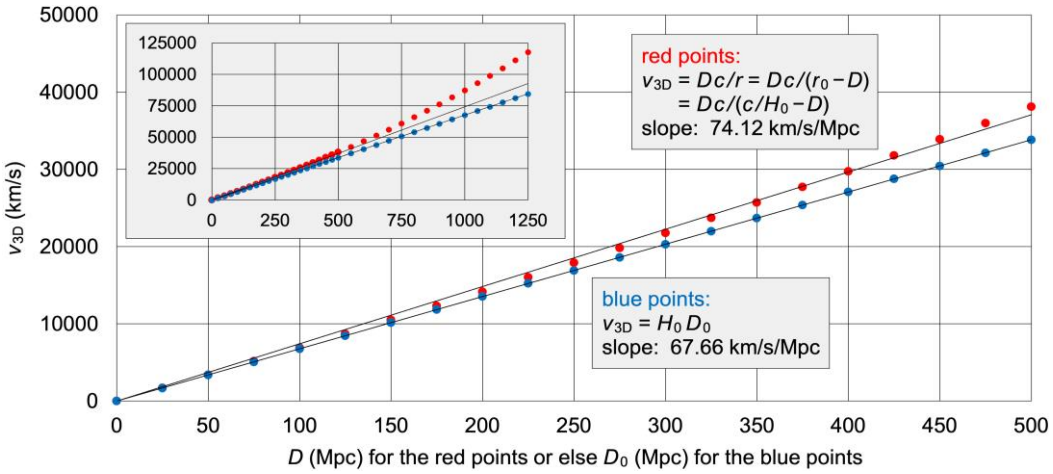

Figure 6. Hubble diagram of simulated supernovae at distances up to 1250 Mpc. The horizontal axis is D for the red points or else D_0 for the blue points. The red points were calculated from Eq. (19). They do not yield a straight line because H_t is not a constant. The blue points were calculated from Eq. (20). 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. (20) as

$$v_{3D,0} = D\,c/r_0 = H_0\,D\ , \tag{22}$$

where $v_{3D,0}$ is today's 3D speed of another star S_0 (Fig. 5 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. (21) with Eqs. (19) and (22). This gives us

$$H_t = H_0\,c/(c - H_0\,D) = H_0/(1 - v_{3D,0}/c)\ , \tag{23}$$

$$v_{3D,0} = v_{3D}/(1 + v_{3D}/c)\ . \tag{24}$$

By applying Eq. (24), all red points in Fig. 6 drop down to the points marked in blue. Of course, team B is well aware that the supernova's light was emitted in the past, but all that counts in the Lambda-CDM model is the timespan during which the light is moving to Earth. Along the way, each wavelength is continuously stretched by expanding space. The redshift parameter z increases during the journey to Earth.

In the ER-based model, all that counts is the moment when the supernova occurred. Each wavelength is initially redshifted by the Doppler effect. Here the redshift parameter z remains constant during the journey to Earth. It is tied up in some "package" when the supernova occurs and then sent to Earth, where it is measured by physicists. Space is not expanding. Rather, energy is receding from the origin O of ES (location of the Big Bang). ***In ER, expanding space is an obsolete concept.***

5.12. Solving 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. (24). 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. Perlmutter et al. (1998) and Riess et al. (1998) advocate an accelerating expansion because the calculated recession speeds deviate from a straight line in the Hubble diagram and the 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_t deviates from H_0, and the more v_{3D} deviates from $v_{3D,0}$. If another star S_0 (Fig. 5 right) happens to be at the same distance of $D = 400$ Mpc today at which the supernova of star S occurred, Eq. (24) 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 a "dark energy" (Turner, 1998). However, dark energy has never been observed. It is a stopgap for an effect that the Lambda-CDM model cannot explain.

For $D > 500$ Mpc, the red points in Fig. 6 run away from a straight line. It is the same secret that solves the Hubble constant tension and dark energy: *In Eq. (20), D_0 must not be confused with D.* Because of Eq. (19) and $H_t = c/(r_0 - D)$, the recession speed v_{3D} is not proportional to D but to $D/(r_0 - D)$. Any expansion of space—uniform or accelerating—is only virtual. There is no accelerating expansion of space even if a Nobel Prize in Physics was given "for the discovery of the accelerating expansion of the Universe through observations of distant supernovae" (The Nobel Foundation, 2011). There are two misconceptions in these words of praise: (1) In the Lambda-CDM model, Universe implies space, but space is not expanding. (2) All but the nearest galaxies recede from Earth, but they do so uniformly. There is no acceleration. ***In ER, dark energy is an obsolete concept.*** Note that this result casts doubt on the Lambda-CDM model but not on GR.

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 1 compares two models of cosmology. Note that "Universe" (Lambda-CDM model) and "universe" (ER-based model) are not the same thing. The "universe" is an observer's proper space. Thus, each observer experiences his own "universe". In the next two sections, ER proves to be compatible with QM. Since all versions of quantum gravity are meant to make GR compatible with QM, we conclude: ***In ER, quantum gravity is an obsolete concept.***

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.
GR is not compatible with quantum mechanics.	ER is compatible with quantum mechanics.

Table 1. Comparing two different models of cosmology.

5.13. Solving the Mystery of the Wave–Particle Duality

The wave–particle duality was first discussed by Bohr and Heisenberg (Heisenberg, 1969) and has bothered physicists ever since. 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 now solve the duality by replacing waves and particles with the objective concept "pure energy". Just to visualize pure energy, I coin the word "wavematter" (Fig. 7). 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). The wave propagates and oscillates as a function of coordinate

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time because we talk about an observer's reality. 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. Note that "wavematter" is not just another word for the wave–particle duality. It is an objective concept of energy that takes the internal view of photons into account. In today's physics, there is no internal view of a photon.

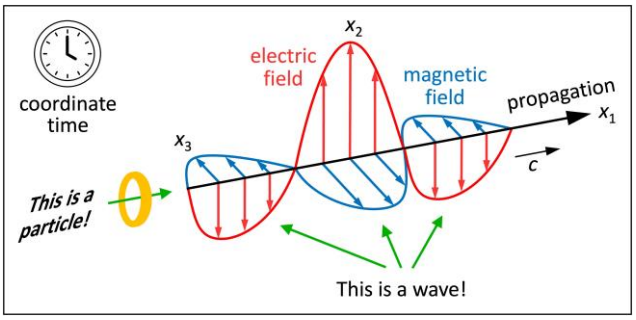

Figure 7. Illustration of a wavematter. In an observer's reality (external view), a wavematter appears as a wave packet or as a particle. As a wave (shown here), it propagates and oscillates as a function of coordinate time. In its own reality (internal view), the axis of the wavematter's 4D motion disappears because of length contraction at the speed c. It deems itself particle at rest.

Like coordinate space/coordinate time, waves/particles are subjective concepts: *What I deem wave, deems itself particle at rest.* Energy is equivalent to mass (Einstein, 1905c). This equivalence causes the duality and was my inspiration for the word "wavematter". Since each wavematter moves at the speed c, the axis of its 4D motion disappears for itself. In its reality, all of its energy "condenses" (concentrates) to what we call "mass".

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 decisive factor.* The photon behaves like a particle.

A duality is also observed in matter, such as electrons (Jönsson, 1961). Electrons, too, are wavematters. Electrons behave like a wave 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, celestial bodies, etc.

5.14. Solving the Mystery of Entanglement

The term "entanglement" was coined by Schrödinger (1935) in his comment on the Einstein–Podolsky–Rosen paradox (Einstein et al., 1935). These three authors argued that QM would not provide a complete description of reality. Schrödinger's word creation did not solve the paradox but demonstrates our difficulties in comprehending QM. Bell (1964) showed that local hidden-variable theories are not compatible with QM. In experiments (Freedman & Clauser, 1972; Aspect et al., 1982; Bouwmeester et al., 1997), entanglement violates locality. Entanglement has been considered a non-local effect ever since.

Up next, we untangle entanglement without the concept of non-locality. All we need is ER: The objective concept "pure distance" makes non-locality obsolete. Fig. 8 illustrates two wavematters that were created at once at a point P. They move away from each other in opposite directions $\pm d'_4$ at the speed c. As it turns out, these two wavematters 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 cannot understand how they are able to communicate with each other in no time.

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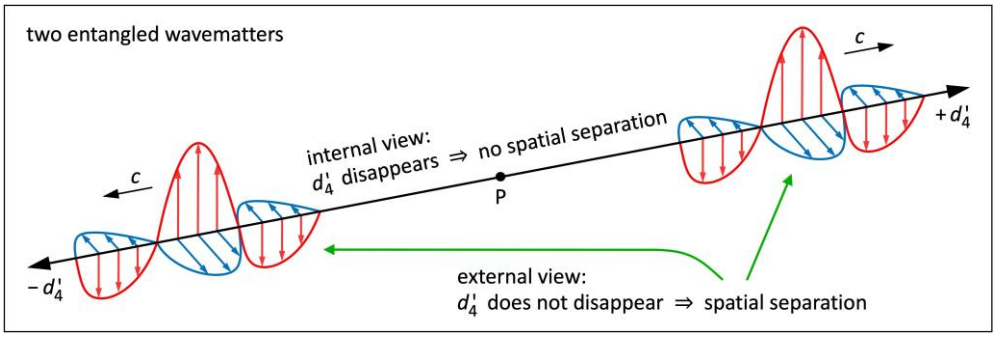

Figure 8. Two wavematters moving in $\pm d_4'$ at the speed c are spatially separated for an observer moving in any direction other than $\pm d_4'$ (external view). For each wavematter (internal view), the d_4' axis disappears. From the internal view, the twins have never been separated spatially.

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 there is a gap in proper time between them and their proper time flows in opposite 4D directions. *For either twin, the other twin is a reflection of itself—not in proper space but in proper time.* Thus, the twins do not communicate with each other, but all actions of either twin are mirrored. The reflection is instantaneous because the speed limit for information applies to space but not to time. Memorizing the past does not take time. There is a "spooky action at a distance" from the external view only.

It is the same secret that solves the horizon problem and entanglement: *An observer's proper space may differ from an observed region's (object's) proper space.* This is possible only if all d_μ are interchangeable. ER also explains the entanglement of matter, such as electrons (Hensen et al., 2015). Electrons, too, move in d_4' at the speed c. A measurement destroys the reflection and thus the entanglement. ***In ER, non-locality is an obsolete concept.***

5.15. Solving 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. Scientific theories must be falsifiable (Popper, 1935).

6. Conclusions

ER solves mysteries that have not been solved in 100+ years—or else that have been solved but with concepts that are obsolete in ER: cosmic inflation, expanding space, dark energy, quantum gravity, non-locality. Today's physics needs these concepts to make cosmology and QM work, but Occam's razor shaves them off. Thus, physics would be well advised to accept ER. This implies: (1) We limit the scope of SR/GR to an observer's reality. (2) We internalize that the master reality ES (described by ER) is beyond each observer's reality (described by SR/GR). (3) In cosmology and QM, we waive all obsolete concepts and build only on objective concepts, such as pure distance and pure energy.

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SR/GR are considered two of the greatest achievements of physics because they have been confirmed many times over. I showed that SR/GR do not provide a holistic view, and I can imagine that this constraint is causing the stagnation in today's physics. Physics got stuck in its own concepts. ER solves 15 mysteries of physics geometrically—without field equations. This tells us that there is a lot more to uncover beyond SR/GR. I consider it very unlikely that 15 solutions in various (!) areas of physics are nothing but 15 coincidences. Only in ES 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.

It was a wise decision to award Albert Einstein the Nobel Prize for his theory of the photoelectric effect (Einstein, 1905a) and not for SR/GR. 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. I sacrifice the absolute nature of waves and particles, but absolute, cosmic time is restored. 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. Physics is the science of describing the universe and its interior. Our primary source of knowledge is observing, but—if we limit physics to observing—even cosmology and QM would be metaphysical. They are built on assumptions that go beyond observing. *Observing is always wedded to egocentric perspectives that may give rise to mysteries.* ER solves the Hubble constant tension and entanglement by describing nature in her own, objective, natural concepts (pure distance, pure energy) rather than in the concepts of an observer. Since ER helps us understand what we observe, it is a physical theory.

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 not compatible with QM unless we formulate quantum gravity or the like. Einstein's concept of gravity works well in GR, but it is not valid in ER. (2) I introduced ER in Eq. (4) by defining its metric. Since we cannot measure proper coordinates of objects, we cannot derive ER from measurement instructions. (3) Absolute, cosmic time brings all speculations about time travel to an end. Does any other theory solve time's arrow and all of the other 14 mysteries as beautifully as ER? (4) 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 probability function? *Dark energy and non-locality are far more speculative than projections.* (5) It looks like Plato's *Allegory of the Cave* is correct: Mankind experiences projections that are blurred—because of QM.

It is not by chance that the author of this paper is an experimental physicist. Several prominent theorists told me that ER would be nonsense. I laid the groundwork for ER and showed how powerful it is. Paradoxes are only virtual. *The pillars of physics are SR/GR, ER, and QM.* Together, they describe an observer's reality and the master reality from the very large to the very small. Introducing a holistic view to physics is what I consider the most innovative part of this paper. The holistic view holds new information that is not provided if all egocentric perspectives are taken together. Everyone is welcome to solve even more mysteries in ER. May ER get the broad acceptance that it deserves!

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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 my paper was rejected by several journals. Interestingly, I was never given any solid arguments. 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? Even friends refused to support me. However, each setback inspired me to work out the benefits of ER even better. Finally, I succeeded in disclosing an issue in SR/GR and in formulating a new theory that is even more general than GR. Some physicists have difficulties in accepting ER because the SO(4) symmetry of ES is incompatible with waves. Well, ER is not disputing waves but limiting their occurrence to an observer's reality. These comments shall encourage young scientists to stand up for promising ideas, but be aware that opposing the mainstream is exhausting. Here are some statements that I received from top journals: "Unscholarly research." "Fake science." "Too simple to be true." Well, just as the retrograde loops are obsolete in the heliocentric model, so is the calculus of GR obsolete in ER. The editor-in-chief of a top journal replied: "Publishing is for experts only." arXiv suspended my submission privileges. *Simple and true are not mutually exclusive. Beauty is when they go hand in hand.*

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References

Abbott, B. P., et al. (2016). Observation of gravitational waves from a binary black hole merger. *Physical Review Letters, 116*(6), 061102. https://doi.org/10.1103/PhysRevLett.116.061102

Aghanim, N., et al. (2020). Planck 2018 results. VI. Cosmological parameters. *Astronomy & Astrophysics, 641*, A6. https://doi.org/10.1051/0004-6361/201833910

Almeida, J. B. (2001). An alternative to Minkowski space-time. arXiv:gr-qc/0104029. https://doi.org/10.48550/arXiv.gr-qc/0104029

Ashby, N. (2003). Relativity in the global positioning system. *Living Reviews in Relativity, 6*(1), 1–42. https://doi.org/10.12942/lrr-2003-1

Aspect, A., Dalibard, J., & Roger, G. (1982). Experimental test of Bell's inequalities using time-varying analyzers. *Physical Review Letters, 49*(25), 1804–1807. https://doi.org/10.1103/PhysRevLett.49.1804

Bell, J. S. (1964). On the Einstein Podolsky Rosen paradox. *Physics, 1*(3), 195–200. https://doi.org/10.1103/PhysicsPhysiqueFizika.1.195

Bouwmeester, D., et al. (1997). Experimental quantum teleportation. *Nature, 390*, 575–579. https://doi.org/10.1038/37539

Dyson, F. W., Eddington, A. S., & Davidson, C. (1920). A determination of the deflection of light by the sun's gravitational field, from observations made at the total eclipse of May 29, 1919. *Philosophical Transactions of the Royal Society A, 220*, 291–333. https://doi.org/10.1098/rsta.1920.0009

Einstein, A. (1905a). Über einen die Erzeugung und Verwandlung des Lichtes betreffenden heuristischen Gesichtspunkt. *Annalen der Physik, 322*(6), 132–148. https://doi.org/10.1002/andp.19053220607

Einstein, A. (1905b). Zur Elektrodynamik bewegter Körper. *Annalen der Physik, 322*(10), 891–921. https://doi.org/10.1002/andp.19053221004

Einstein, A. (1905c). Ist die Trägheit eines Körpers von seinem Energieinhalt abhängig? *Annalen der Physik, 323*(13), 639–641. https://doi.org/10.1002/andp.19053231314

Einstein, A. (1916). Die Grundlage der allgemeinen Relativitätstheorie. *Annalen der Physik, 354*(7), 769–822. https://doi.org/10.1002/andp.19163540702

Einstein, A., Podolsky, B., & Rosen, N. (1935). Can quantum-mechanical description of physical reality be considered complete? *Physical Review, 47*(10), 777–780. https://doi.org/10.1103/PhysRev.47.777

Freedman, S. J., & Clauser, J. F. (1972). Experimental test of local hidden-variable theories. *Physical Review Letters, 28*(14), 938–941. https://doi.org/10.1103/PhysRevLett.28.938

Gersten, A. (2003). Euclidean special relativity. *Foundations of Physics, 33*(8), 1237–1251. https://doi.org/10.1023/A:1025631125442

Guth, A. H. (1997). *The inflationary universe.* Perseus Books.

Hafele, J. C., & Keating, R. E. (1972). Around-the-world atomic clocks: Predicted relativistic time gains. *Science, 177*, 166–168. https://doi.org/10.1126/science.177.4044.166

Heisenberg, W. (1969). *Der Teil und das Ganze.* Piper.

Hensen, B., et al. (2015). Loophole-free Bell inequality violation using electron spins separated by 1.3 kilometres. *Nature, 526*, 682–686. https://doi.org/10.1038/nature15759

Hubble, E. (1929). A relation between distance and radial velocity among extra-galactic nebulae. *Proceedings of the National Academy of Sciences of the United States of America, 15*(3), 168–173. https://doi.org/10.1073/pnas.15.3.168

Jönsson, C. (1961). Elektroneninterferenzen an mehreren künstlich hergestellten Feinspalten. *Zeitschrift für Physik, 161*, 454–474. https://doi.org/10.1007/BF01342460

 doi:10.20944/preprints202207.0399.v71

Kant, I. (1781). *Kritik der reinen Vernunft.* Hartknoch.
Lemaître, G. (1927). Un univers homogène de masse constante et de rayon croissant, rendant compte de la vitesse radiale des nébuleuses extra-galactiques. *Annales de la Société Scientifique de Bruxelles A, 47*, 49–59.
Linde, A. (1990). *Inflation and quantum cosmology.* Academic Press.
Minkowski, H. (1910). Die Grundgleichungen für die elektromagnetischen Vorgänge in bewegten Körpern. *Mathematische Annalen, 68*, 472–525. https://doi.org/10.1007/BF01455871
Montanus, J. M. C. (1991). Special relativity in an absolute Euclidean space-time. *Physics Essays, 4*(3), 350–356.
Montanus, J. M. C. (2001). Proper-time formulation of relativistic dynamics. *Foundations of Physics, 31*(9), 1357–1400. https://doi.org/10.1023/A:1012274211780
Montanus, H. (2023, September 23). *Proper Time as Fourth Coordinate.* ISBN 978-90-829889-4-9. Retrieved May 1, 2024, from https://greenbluemath.nl/proper-time-as-fourth-coordinate/
Newburgh, R. G., & Phipps Jr., T. E. (1969). A space–proper time formulation of relativistic geometry. *Physical Sciences Research Papers (United States Air Force),* no. 401.
Newton, I. (1687). *Philosophiae naturalis principia mathematica.* Joseph Streater.
Niemz, M. H. (2020). *Seeing our world through different eyes.* Wipf and Stock. Original German version: Niemz, M. H. (2020). *Die Welt mit anderen Augen sehen.* Gütersloher Verlagshaus.
Penzias, A. A., & Wilson, R. W. (1965). A measurement of excess antenna temperature at 4080 Mc/s. *The Astrophysical Journal, 142,* 419–421. https://doi.org/10.1086/148307
Perlmutter, S., et al. (1998). Measurements of Ω and Λ from 42 high-redshift supernovae. arXiv:astro-ph/9812133. https://doi.org/10.48550/arXiv.astro-ph/9812133
Plato. *Politeia,* 514a.
Popper, K. (1935). *Logik der Forschung.* Julius Springer.
Riess, A. G., et al. (1998). Observational evidence from supernovae for an accelerating universe and a cosmological constant. *The Astronomical Journal, 116*(3), 1009–1038. https://doi.org/10.1086/300499
Riess, A. G., et al. (2018). Milky Way Cepheid standards for measuring cosmic distances and application to Gaia DR2. *The Astrophysical Journal, 861*(2), 126. https://doi.org/10.3847/1538-4357/aac82e
Rossi, B., & Hall, D. B. (1941). Variation of the rate of decay of mesotrons with momentum. *Physical Review, 59*(3), 223–228. https://doi.org/10.1103/PhysRev.59.223
Ryder, L. H. (1985). *Quantum field theory.* Cambridge University Press.
Schrödinger, E. (1935). Die gegenwärtige Situation in der Quantenmechanik. *Naturwissenschaften, 23*, 807–812. https://doi.org/10.1007/BF01491891
The Nobel Foundation (2011). *The Nobel Prize in Physics 2011.* Retrieved May 1, 2024, from https://www.nobelprize.org/prizes/physics/2011/summary/
Turner, M. S. (1998). Dark matter and dark energy in the universe. arXiv:astro-ph/9811454. https://doi.org/10.48550/arXiv.astro-ph/9811454
van Linden, R. (2023). *Euclidean relativity.* Retrieved May 1, 2024, from https://euclideanrelativity.com
Weyl, H. (1928). *Gruppentheorie und Quantenmechanik.* Hirzel.
Wick, G. C. (1954). Properties of Bethe-Salpeter wave functions. *Physical Review, 96*(4), 1124–1134. https://doi.org/10.1103/PhysRev.96.1124